AN ANALYSIS OF THE NON-ADOPTION OF AN INTRODUCED CONSERVATION AGRICULTURE (CA) PROGRAM BY VILLAGE FARMERS IN SĀMOA

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To my children;
Rosemary Sulifoa and Richard Andrew Sulifoa.

To the farmers in Samoa who continue to struggle daily.

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ABSTRACT

With soil health declining in Samoa, interest in introducing Conservation Agriculture (CA) practices to improve crop yields and livelihoods has been ongoing since the 1970s. Despite the efforts of the institutions involved in the introduction of CA practices under different programs, village farmers have not adopted these CA practices.

No universal theory explains why farmers adopt or reject a new idea. However, in the case of Samoa, labor issues due to out-migration and differences in perceptions of those involved in the implementation of programs could be hindrances to the adoption of these introduced programs. Thus, this study hypothesized that: (1) stakeholder differences impacted adoption and continued use of CA systems, and (2) labor availability constrained producers' ability to use CA systems. Four specific studies were undertaken in order to test these hypotheses,: (1) an investigation of the rate of adoption and stakeholder participation in introduced CA programs in Samoa; (2) a comparison of the benefits and costs of the introduced systems relative to current practices; (3) an investigation of the socio-economic and cultural factors influencing farmers' decisions to not adopt an introduced CA practice; and (4) the identification of stakeholders differences in goals, objectives and perceptions relative to an introduced CA practice.

Ninety-one published and unpublished sources between 1970 and 2015 were reviewed, providing an overview of the introduced CA programs. Four CA programs have been introduced in Samoa, however, three were introduced so long ago that information on their effectiveness or ineffectiveness was extremely hard to find. Therefore, this study focused on the most recent program. i.e., the Soil Health Program utilizing mucuna (*Mucuna pruriens*) as a cover crop. In-depth interviews with farmers and key informants, participant observation, and focus group discussions were used to develop an understanding of the perceived issues with the introduced CA practice and an Analytic Hierarchy Process (AHP) was used to illustrate differences in stakeholder perceptions.

Although a variety of resources were used in the programs implemented, the farmers were not convinced about the potential benefits of the introduced CA practices. Mucuna as a cover crop did not provide any relative advantage, was too complex and was not compatible with current practices, thereby requiring farmers to change their mindset in order to implement the system. Furthermore, not all farmers were included in the outreach efforts and farmers were not given enough time to test the introduced system to observe its relative benefits and limitations. Uncertainties associated with the introduced CA practice made farmers unwilling to take the risk of changing their current practices. The risk was perceived as serious as they depend on agriculture for their food and for income to fulfill their cultural obligations. The final study shows that differences exist in the perceptions of extension officers who are responsible for program outreach efforts to that of the farmers.

More involvement of all farmers needs to be considered in the future with CA programs being introduced through the village councils within the respective villages in Samoa. Donors, government agencies and research institutions involved in the implementation of CA programs need to consider spending more time demonstrating their proposals with farmers and comparing these systems with current practices to help farmers reduce their uncertainty. Farmers should be involved from the beginning of the programs so that better management strategies can be utilized to help adapt the mucuna to suit their needs.

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1.1 Introduction

1.1.1. The significance of smallholder farmers in Samoa

There are some 0.9 billion people who reside in rural areas and are dependent on agriculture for their livelihood (FAO, 2014). These smallholder farmers who play a key role in addressing hunger and nutrition issues in their countries are the most disadvantaged (FAO, 2014). Smallholder farming (here referred to as "village agriculture") has always been a dominant way of life and the mainstay of Pacific Island Countries' (PIC)[1] economies (FAO, 2012). It will continue to provide food and income security for PIC populations.

Samoa is a small PIC located south of the equator, about halfway between Hawaii and New Zealand. It is within Oceania's Polynesian region. It has a total land area of 2,842 km^2 comprised of two main islands, Upolu and Savaii, and several adjacent islets. Close to three-quarters of Samoa's population is dependent on village agriculture for its livelihood. These farmers operate predominately at the subsistence and semi-subsistence levels under a customary land tenure[2] system. The family chief (*Sa'o*) holds the overall responsibility for the distribution of land to his or her family members (O'Meara, 1990; Meleisea & Schoeffel, 2015). Farming labor activities are carried out by members of a given household[3] within the *'aiga* (Paulson, 1997; Ward & Ashcroft, 1998).

[1] PICs are generally defined as the islands of the Pacific Ocean; the three broad groups include Melanesia, Micronesia and Polynesia.
[2] Family members communally own land.
[3] Household in this paper is defined as one or more persons who live together and have their meals together (Agriculture Census, 1999), the *'aiga* is comprised of separate households.

1.1.2. Factors contributing to agricultural decline in Samoa

Today, Samoa's economy is dependent on foreign aid, remittances, and tourism (Fairbairn, 1993; Central Bank of Samoa, 2011-2012; Connell, 2015). Yet in the 1980s, agriculture was the main driver of Samoa's economy, contributing 50 percent of the total Gross Domestic Product (GDP)[4] and its contribution declined to less than 10 percent of GDP in 2014. Figure 1 shows a decline in the contribution of agriculture to the overall GDP relative to the overall growth of the economy.

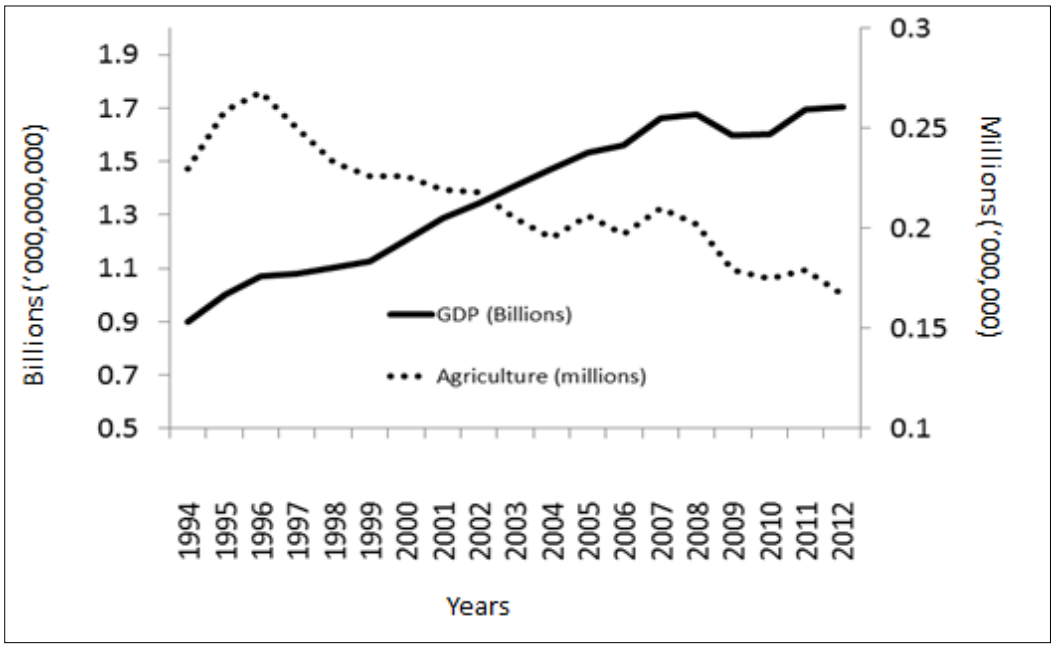

Figure 1: Gross Domestic Product (GDP) and Agriculture (values in constant dollars).
(Source: Central Bank of Samoa, 2011-2012)

The stagnation of village agriculture in Samoa has been attributed to a set of complex factors, which hinders crop production[5] and reduces yields. These include social, political and environmental issues (O'Meara, 1990; Paulson, 1994; Agriculture Sector Plan, 2011-2015). For many years, regional and international institutions have stressed the importance of soil health as

[4] GDP for the agriculture sector is measured as follows: the amount of domestically consumed crops (fruits, vegetables, nuts), livestock, and export produce including manufactured agricultural goods with a significant fresh produce component (Central Bank of Samoa, 2011-2015).

[5] Crop production in this study is defined as the growing of crops for domestic use or for sale. In cases where the study refers to taro production, it means the growing of taro for domestic use for the family and/or for sale as an export crop or in the local market.

one factor contributing to the decrease in agricultural production (Mercer and Scott, 1958; Blakemore, 1973; Guinto et al., 2015; Anand, 2016). It is a matter that has initiated various academic research and programs in Samoa.

1.1.3. Soil health and its importance

Soil health is important because healthy soils maintain a balanced and diverse community of organisms which live in a symbiotic relationship with plants, supporting its growth through nutrient cycling, improving soil structure and hence the water and nutrient holding capacity of the soil which in turn improves crop production (FAO, 2008; USDA-NRCS, 2012). The critical components of soil health encompass a balance between the biological, chemical, and physical soil characteristics as illustrated in Figure 2.

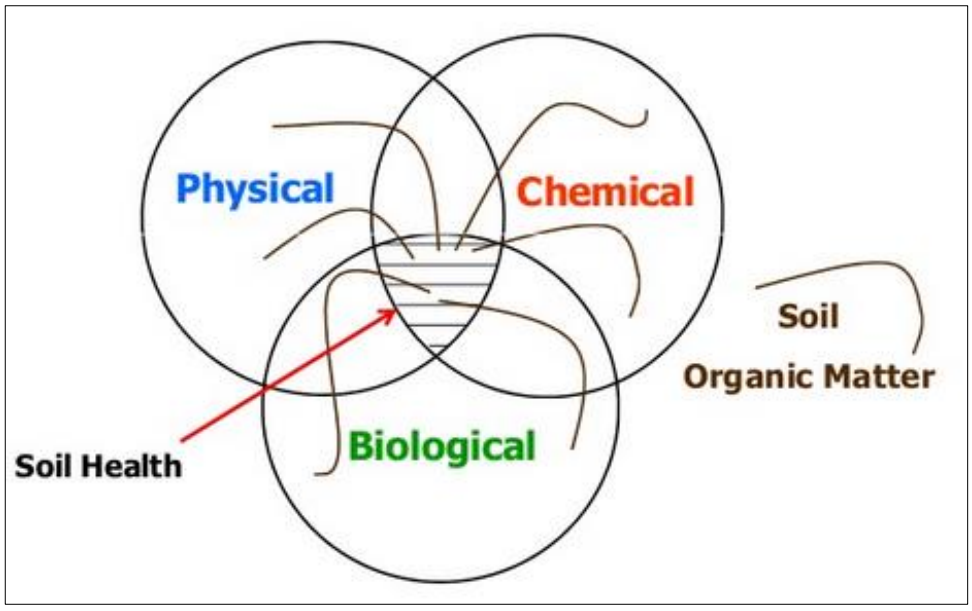

Figure 2: Components of soil health (Source: Diver, 2012)

Soil Organic Matter (SOM) is composed of anything that has once lived and it is created by the cycling of organic compounds in plants, animals, and microorganisms found in the soil. Around five percent of the soil volume is composed of SOM (USDA, 1996). It maintains the biological, physical, and chemical functions of the soil through the provision of carbon and energy for soil

microbes; it holds soil particles together hence reducing soil erosion. It also holds onto air and water, which are important in plant growth. Furthermore, SOM is significant because it stores and supplies important soil macronutrients and micronutrients needed for plant growth and microorganism functioning. It is of great importance to the soils Cation Exchange Capacity (CEC[6]). Maintaining this balance through sufficient SOM is critical particularly for tropical soils due to its thin soil layer, and limited fertility (Haynes & Naidu, 1989).

Issues with soil health in Samoa began emerging in the late 1980s at the time of peak taro (*Colocasia esculenta*) production. According to Ofori (n.d.) taro yields (kg/ha) during this time have been declining while cultivation areas[7] have increased slightly (Figure 3). Before the TLB era, yield decline was attributed to the unsustainable farming practices such as shortened fallow periods and intensive cultivation of taro on the same piece of land resulting in declining soil fertility and SOM (Mercer & Scott, 1958; Rosecrance et al., 1992; ACIAR, 2015).

After 20 years of research and breeding programs, new taro breeds emerged and were distributed to farmers. Since the early 2000s, taro farming has steadily increased with herbicide use facilitating intensive cultivation because farmers can clear larger land areas with limited labor (Agriculture Sector Plan, 2011-2015). Stakeholders involved in agricultural work are concerned about a repetition of taro yield decline as per the pre TLB period (M.I. personal communication, September 21, 2016). Recent studies by Guinto et al., (2015) and Anand (2016) have indicated soil health issues such as low pH levels as well as low Phosphorous and Potassium levels in the soil.

[6] Cation-Exchange Capacity is a measure of the soil's ability to retain moisture and nutrients.
[7] Areas under subsistence and semi-subsistent cultivation in Samoa remain the same throughout the year. The only difference is that farmer's leave these areas fallow for a length of time, depending on the land area and labor available to the farmer.

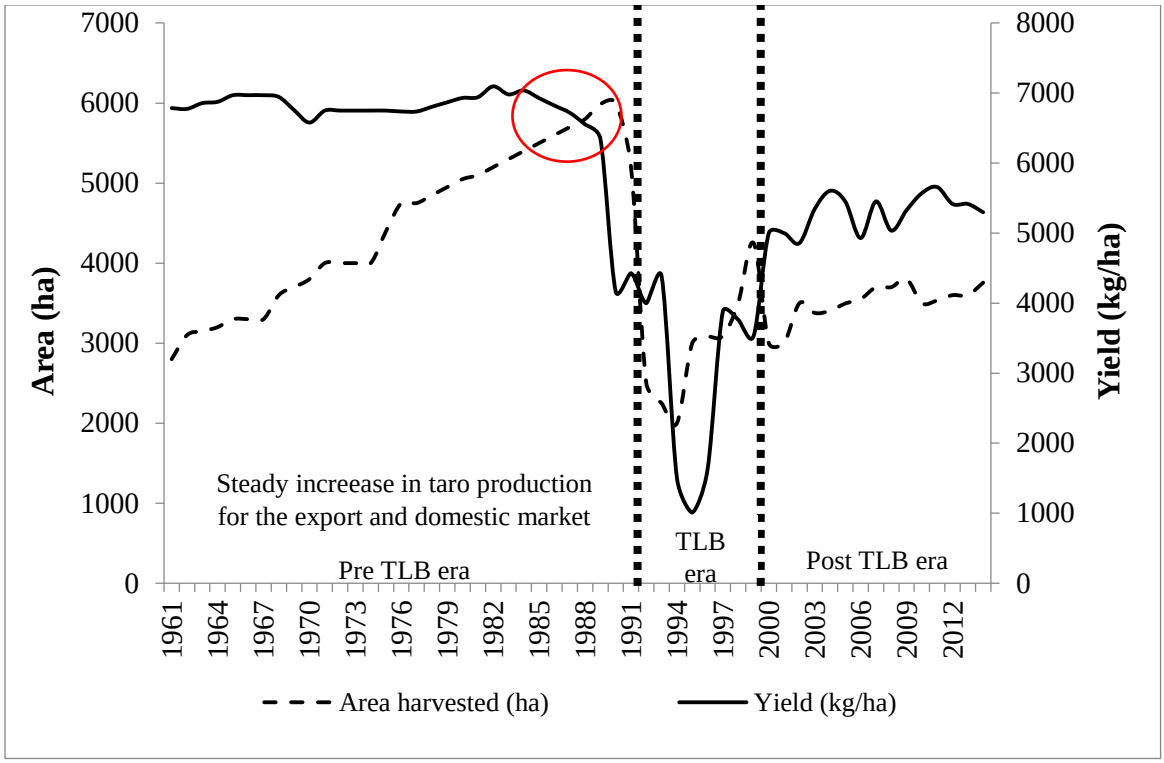

Figure 3: Taro yield (kilograms per hectare) and land area (hectares) from the 1960s to 2014. These taro values take into account *Colocasia esculenta*, *Alocasia macrorrhiza*, *Xanthosoma spp.* The bold dotted lines indicate the different epoch i.e. pre TLB, TLB era and post TLB era (Source: FAOSTAT, September 2017)

1.1.4. Conservation Agriculture and its benefits

One way to combat soil health issues is through Conservation Agriculture (CA). According to FAO (2010) the term encompasses three key farming characteristics: (1) minimal mechanical soil disturbance (i.e. zero-tillage and direct seeding); (2) maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops); and (3) rotations or sequences and associations of crops including trees which could include nitrogen-fixing legumes.

Farmers in the United States adopted CA after experiencing a drought (aka the dust bowl) which devastated wide areas of the mid-west United States in the 1930s (Friedrich et al., 2012). Intensive tillage and lack of soil cover magnified the drought. The concepts of conservation

tillage and soil cover were introduced to protect the soil. Scientists and farmers in Brazil adapted the no-tillage system to suit their farming needs. CA spread to other parts of South America such as southern Brazil, Argentina, and Paraguay in the 1990s. The system attracted the attention of international organizations such as the Food and Agriculture Organization of the United Nations (FAO) and the World Bank, which further expanded both the awareness and the introduction of the technology to other parts of the world such as Africa and Asia. CA is implemented either as individual components (Andersson & D'Souza, 2014) or as an integration of these components as a system.

1.1.4.1. Environmental benefits

Reduced or zero-tillage is important for minimizing soil erosion and water runoff (Lanckriet et al., 2012), reducing wind erosion (Friedrich et al., 2012), reducing the formation of hardpan layers in soils, increasing infiltration of water in the ground and slowing the breakdown of SOM in the soil (Gliessman, 2014). Village farmers in Samoa use zero-tillage. Mechanization is limited because the soils are rocky and land area is limited (Agriculture Sector Plan, 2011-2015).

Reduced soil tillage leads to less fuel usage which helps mitigate greenhouse gas emissions (Liebig et al., 2005; Sapkota et al., 2014; Pratibha et al., 2015). Other notable impacts of CA with the use of zero-tillage and residue retention saw reduced soil runoff and improved SOM, increased CEC and microbial activity (Lienhard et al., 2013; Gliessman, 2014). In addition, studies on crop rotation using either a legume or non-legume plants resulted in improved moisture retention, increased infiltration and a reduction in specific pests and diseases of crops (Thierfelder et al., 2013). These factors are pertinent to smallholder farmers in Samoa because the cost of agricultural inputs like chemical fertilizers and pesticides to sustain yields is high (Agriculture Sector Plan, 2011-2015).

1.1.4.2. Yield and profit improvement over time

Other noticeable benefits of CA through crop rotation or intercropping is through crop diversification which ultimately provides better economic returns (Mishra et al., 2015; Lanckriet et al., 2012; Thierfelder et al., 2013). Pradhan (2015) reported that the addition of horse gram *(Macrotyloma uniflorum)* as part of an intercropping system with maize and the inclusion of

mustard as a cover crop resulted in a 228 percent higher marginal benefit compared to the conventional system of sole maize cropping. Similar findings were made by Laik et al., (2014) on a system of potato and maize-rice-cowpea rotation.

Aulakh et al., (2011) showed the benefits of CA in soils that were poor in organic carbon and had low available phosphorus. The study revealed that crop rotation with wheat and soybean resulted in yields that were six percent higher compared to conventional systems. Similar findings on yield improvement and improved economic returns were illustrated by Stonehouse, 1997; Hobbs (2007); Lienhard et al., (2013); Thierfelder et al., (2013); Laik et al., (2014) and Sapkota et al.,(2014).

Most yield increases reported did not occur immediately but gradually over time (Jeranyama et al., 2000; Lai et al., 2012; Jat et al., 2014) because time is needed to identify the right crop combination suitable for the farmer's needs. It also takes time for the whole system (biological, physical, and chemical processes) above and below ground to find its balance and become sustainable. During this trial and error period, incentives supported farmers until income can be sustained (Retrieved IFAD, March 2016).

1.1.4.3. Socio-economic benefits

In situations where monocropping was previously practiced by farmers, crop diversity has the potential to improve the overall nutritional intake of smallholder farmers. For example, Paudel et al., (2015) reported that although CA in the form of maize-legume and maize-millet-legume systems with conventional tillage did not increase the yields of individual crops, CA did increase food availability due to increased crop diversity.

1.1.5. The (non) adoption of Conservation Agriculture worldwide and in Samoa

Although CA systems hold much potential, its adoption by farmers particularly in the developing countries has been either slow or absent (Giller et al., 2009; Corbeels et al., 2014). In the case of Samoa, CA research has indicated the potential of the system to improve soil health, however, observations have shown that these systems introduced into farming communities have often

resulted in its non-adoption (T.I., personal communication, December 17, 2016). Literature suggests that there is no blueprint to explain why some farmers adopt CA practices and others do not. This is because each situation is site and context specific (Knowler & Bradshaw, 2007). Literature also suggests that limitations such as the lack of information regarding the use of the system, the perceived socio-economic risks, delayed yield and profit benefits, as well as the lack of incentives for farmers to use the system, limits its adoption.

1.1.5.1. Limited information and perceived risk

Factors such as the limited understanding of the problems faced by the smallholder farmers (Andersson & D'Souza, 2014) could limit the adoption of CA. While CA practices are considered sustainable[8], the shift from short-term profit to long-term sustainability is difficult for small farmers with limited resources due to the high cost of waiting. For example, intercropping was challenging for European farmers because they lacked the information to select compatible cash crops (Shaxson, 2006).

Rust-Smith's, (2015) research in Malawi suggests that understanding farmers' risk perspectives will aid in the adoption of any new technology. Farmers see new technology as unfamiliar and hence, farmers lack the confidence in their ability to execute such a system successfully. Education must go hand in hand with the introduction of these new systems especially for those farmers who are considered vulnerable. Smallholder farmers are reluctant to change their practices if the CA system is perceived as risky (Rust-Smith's, 2015). To overcome these perceptions, policies need to be tailored to the local communities to suit the local beliefs and perspectives of the people who will use it (Rogers, 2003; Palmer et al., 2014; Corbeels et al., 2014; Halbrendt, 2014).

Also, the building of trust between stakeholders involved in CA work such as the donor institutions, the researcher, extension officers, and the farmers is of vital importance in the successful implementation of any introduced technology (Rust-Smith's, 2015). Currently, the Samoan government does not have a well-developed outreach infrastructure to extend research

[8] Sustainability in this study is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Bruntland, Report for the World Commission on Environment and Development (1992).

information to farmers which could be a barrier to the successful execution of a CA system. Furthermore, Samoan village farmers mistrust government officials (Samoa Observer, December 16, 2015), which could be limiting CA adoption.

1.1.5.2. Socio-economic factors

Trials carried out on smallholder farmers in Africa showed CA adoption was slow because it was labor intensive in the initial stages of its implementation (Rola et al., 2009). Farming activities, particularly in developing countries are divided between genders (Lai et al., 2012), and a shift to CA can create a burden on one or both groups (Halbrendt, 2014). Furthermore, studies on the introduction of soil conservation technologies in the Philippines showed that a need to hire labor had an adverse impact on adoption because of the high cost associated with payment and supervision time (Rola et al., 2009). Labor could be a challenge for the local village farmers in Samoa because of urbanization and out-migration resulting in declining rural population households (Agriculture Sector Plan, 2011-2015).

1.1.5.3. Lack of incentives

Yield improvement is not immediately visible with CA and can take up to seven years to fully realize the benefits (Jeranyama et al., 2000; Jat et al., 2014; Paudel et al., 2015). Gradual yield improvement generally results in future economic returns (Stonehouse, 1997; Hobbs, 2007; Thierfelder et al., 2013; Laik et al., 2014). However, farmers find it costly to wait for these benefits and need support to encourage them to adopt CA (Andersson & D'Souza, 2013). For example, Hobbs, (2007), reports that after three decades of promoting zero-tillage technologies in the Indo-Gangetic Plains (IGP), the adoption was found to be low because farmers lacked appropriate planting equipment (e.g., seed driller) to conduct the work. Due to the various challenges with the initial set up of CA Kassam et al., (2009) predicts that the adoption of the system will continue to be slow particularly with the smallholder farmers in the developing countries where incentives could prove to be too costly.

1.1.5.4. Farmers perception of Conservation Agriculture

Rogers, (2003) diffusion theory suggests that the four key elements that explain adoption patterns include the characteristics of the innovation, the social system, the channels used to

communicate the innovation and time. Local culture, social and economic status, education level, and gender are all factors in a social system that affect farmers perceptions and are important to consider when introducing any new technology. In Samoa, consultation with and education of village farmers may be a key factor in the adoption of CA technology by farming households.

Stakeholders such as farmers, scientists and change agents responsible for CA outreach efforts often have differences in opinions, perceptions, and beliefs (Rogers, 2003; Halbrendt, 2014). These differences are due to the heterophily nature of the stakeholders i.e. differences in their education level, social and economic status as well as their technical expertise (Rogers, 2003). These differences often result in a misunderstanding of communities by change agents responsible for outreach efforts which result in the use of top-down approaches (Dalton et al., 2014). Understanding these differences can facilitate the development of more appropriate education programs for the farmers to facilitate the adoption of introduced CA practices (Dalton et al., 2014).

Effective education and communication are also helpful in assisting potential adopters with evaluating the five characteristics of an innovation that affects adoption, including relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). No evidence suggests how various stakeholder groups in Samoa have developed an outreach or extension program that addresses these elements of the adoption process. In moving from knowing about CA to being persuaded to try to implement it, a range of mass and interpersonal communication should occur (Rogers, 2003).

1.1.6. The goal and objectives of this study

Research conducted worldwide and specifically in Samoa has shown the potential of CA to improve soil health and inevitably crop yields, though introduced CA practices have not been widely adopted in Samoa. The literature in Samoa suggests that differences in perceptions between the change agents or extension officers of CA work relative to those of the local farmers' can hinder both the adoption and the continuation of the systems. Currently, agricultural labor shortages in Samoa could pose a challenge for local village farmers. CA

requires additional labor in the initial stages of its implementation because of the maintenance required for the different crops grown in the system as well as weed control (Corbeels et al., 2014). Furthermore, the government's lack of understanding of village farmers goals is problematic resulting in limited infrastructure to support an outreach effort. A clear understanding of the local farmers can facilitate the adoption of introduced CA practices at the village level.

No blueprint exists for the creation of an environment that will encourage the adoption of CA practices because the human dimensions associated with the decision to adopt CA differs across regions (Knowler & Bradshaw, 2007). To better understand the reasons for the lack of adoption of the introduced CA practices in Samoa, an assessment of the current situation relative to CA was needed. The assessment was also important to understand the interests of the local farmers and all the stakeholders i.e. farmers, donors, extension officers, involved.

The research hypothesized that (1) Stakeholder differences impacted the adoption and the continued use of CA systems. (2) Labor availability constrained producers' ability to use CA systems.

Three specific objectives were addressed:

(1) To investigate the rate of adoption and stakeholder participation for introduced CA programs in Samoa.
(2) To compare the benefits and costs of an introduced CA practice relative to current practices.
(3) To determine the socio-economic and cultural factors influencing farmers' decisions to not adopt an introduced CA practice.
(4) To identify stakeholder differences in goals, objectives, and perceptions of an introduced CA practice.

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Chapter 2

Conservation Agriculture (CA) programs in Samoa and farmer and stakeholder participation: a review of introduced programs 1970 – 2015

Abstract

Farmers in Samoa are dependent on agriculture for food and income. Research institutions working in Samoa have indicated that one of the impediments to agricultural production is a decline in soil health. Conservation Agriculture (CA) practices were introduced under different CA programs to help farmers address this issue. Since no prior study had been carried out to understand the nature of CA work in Samoa, the objective of this study was to investigate the rate of adoption and stakeholder participation of introduced CA programs in Samoa. The study used a literature review and looked at publications focusing on CA research and introduced programs from 1970 to 2015. The study found that four CA programs were introduced to 32 villages in Samoa. The research trials carried out as part of the programs showed positive impact to soil health indicators such as improved crop yield, moisture retention, and reduced weed infestation. However, none of the farmers adopted the introduced practices under the respective programs. This study showed that farmers were not convinced about the potential benefits of the CA practices under the introduced programs due to poor outreach efforts used.

2.1. Introduction

The majority of the Pacific Island Countries (PICs) are dependent on agriculture for their livelihoods (Malua, n.d.; FAO, 2009). These farmers are already disadvantaged because high precipitation and temperatures in their regions increase leaching of soil nutrients and a rapid breakdown of Soil Organic Matter (SOM). As population increases, PIC farmers will be challenged to increase crop production on limited land area with "free-draining and hungry" soils (Barrow, 2013; pg. 30).

Conservation Agriculture (CA) can assist farmers to address these issues and maintain or increase crop production (FAO, 2015). CA is based on a set of three farming principals including reduced soil disturbance, continuous soil organic cover in the form of mulching or

cover cropping and crop rotation or sequences and associations of crops which can include trees and legumes (FAO, 2015). About 1.6 billion hectares (ha) are cultivated worldwide; including an estimated 320 million hectares of marginal land and of these FAO (2017) has classified 157 million hectares as under CA. In Samoa, PIC, scientists and international organizations have conducted research and introduced CA practices under different programs focusing on improving soil health at the village level. Such trials included mulching, agroforestry, mixed cropping, zero-tillage and cover cropping (Mokhtarzadeh, 1986; Reynolds, 1970; Rogers 1992; Iosefa, 1997; Anand, 2016).

Research is important because it is needed to fill specific scientific knowledge gaps associated with CA. Addressing these knowledge gaps will help to localize the systems to suit farmer's conditions (Knowler & Bradshaw, 2007; Arslan et al., 2014). However, research alone will not result in the adoption of an innovation by farmers. According to Rogers (2003) diffusion theory, there are four key elements in the diffusion of an innovation. These include the attributes of the innovation (relative advantage, compatibility, complexity, trialability, and observability), the communication channels used to diffuse the innovation, the overall time spent to diffuse it as well as the social system in the community where the innovation was introduced. Extension professionals who are generally seen as change agents in a community rely on diffusion theory to support community members as they go through the process of adopting an innovation (Rogers, 2003). Researchers generally focus on identifying an innovation and do not assume the responsibility of assisting with the adoption process. Therefore, both research and extension efforts are important to extend CA practices in Samoa (Rogers, 2003).

The government, donors, and non-government organizations have used the logic model or theory of change to provide a clear framework for an intended program; its activities and the fundamental cause-effect relationship to the outputs and outcomes (Framst, 1995 McCawley, 2004). The model is important in the planning, implementation, monitoring, and evaluation of an introduced program. The underlying outcome for CA programs implemented is a change in farmer behavior and the introduced system adopted so that the long-term environment and livelihood continuity of the system can be realized (Pannell et al., 2014). However, despite the well-intentioned programs, its adoption has been slow or limited worldwide (Corbeels et al.,

2014; Dalton et al., 2014). In the case of Samoa, the non-adoption of these introduced CA practices has been observed but relevant data are needed to confirm this (T.T., personal communication, December 16, 2016). This is because results of research conducted on CA practices in Samoa have remained as grey literature with the respective institutions that conducted the studies.

Given the amount of work conducted on CA research and programs in Samoa, the aim of this study was to review the available CA literature from 1970 to 2015 to better understand how the research was conducted and how the CA practices under the respective programs were introduced to farmers as well as the purpose of the research and programs. Furthermore, the study identified the villages and stakeholders (i.e. donors, extension officers or change agents, research institutions) involved and the efforts used to extend the CA practices to farmers as well as the rate of (non) adoption of the implemented CA practices under the respective programs.

2.2. Methodology

2.2.1. Literature review

Following the guidelines by Arksey and O'Malley (2003) and Soni and Kodali, (2012) the literature review was conducted as follows:

Stage 1: Identifying the research question (s)

This research investigated CA research and extension activities that occurred from 1970 to 2015 to encourage the adoption of introduced CA practices by village farmers in Samoa. It also provides insight into why CA practices have or have not been adopted.

Generally, researchers focus on investigating new innovations, not on diffusion related characteristics, particularly research that investigates agricultural production practices. To support the diffusion process, research should focus on the five characteristics of an innovation, including its relative advantage over current practices; it compatibility with existing practices; its complexity from the farmers' perspective; its trialability and observability by farmers.

Innovations which have little relative advantage, are not compatible, cannot be trialed or observed and are complex will likely not be adopted by farmers. Therefore, the literature review determined if the programs attempted to address any of these five characteristics of an innovation and if so, how was it addressed.

Extension activities generally involved the other three key elements of diffusion, including communication channels; time and the social system. During the adoption process, farmers move through five stages of the innovation adoption process from becoming aware of an innovation; being persuaded to consider it as a possibility; to making the decision to try it; then actually completing one or more complete implementation of the innovation and finally confirming for themselves that the innovation is one they will permanently adopt.

Different communication channels are likely to be useful at various stages of the process. Mass communication is useful in the early stages. Face-to-face exchanges are likely to be more useful in the later stages of the innovation adoption process. The behavior of the social system should also be considered at various stages of the process, such as understanding the structure of the relationships and structured communications flows in farming communities and identifying the opinion leaders for various groups (Rogers, 2003). Even during the research phase extension activities such as needs assessments are useful to ensure that the characteristics of the innovation will be consistent with the social and communication system of the farmers. The literature review will investigate to determine if any of these extension activities were undertaken and the timeframe over which these activities extended to facilitate the adoption of CA practices by farmers.

Stage 2: Identifying the timeframe

The literature showed that the earliest CA work in Samoa was by Reynolds (1970) on mulching with the most recent programs conducted by ACIAR (2015) on cover cropping. Therefore, a timeframe of 45 years (1970 – 2015), was used to examine the introduced research and programs and the (non) adoption of the introduced CA practices.

Stage 3: Identifying relevant studies

The initial starting point for the review was the electronic databases at the University of Hawai'i (UH), the University of the South Pacific (USP), and Google Scholar. The CA definition established by FAO (2010) has three primary best practices:

(1) minimal mechanical soil disturbance (i.e. no-tillage and direct seeding);
(2) maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops); and
(3) rotations or sequences and associations of crops including trees which could include nitrogen-fixing legumes

These components were further divided based on the individual example of farming that involves these best practices (Table 1). The type of farming practice(s) was used as keywords for the search. Clear definitions were established as guidance for the literature pursuit. The definitions were taken from reputable textbooks, educational documents, and research, based at USP[9].

The search used secondary information from references indicated in the primary literature. To ensure that the scope of the literature was extensive, the study utilized existing networks, relevant organizations, and knowledgeable personnel (village leaders, farmers, scientists, government officials) that worked and/or are currently working on CA programs in Samoa. This ensured that any reports missing in the initial search may be obtained. Furthermore, discussions with the respective stakeholders confirmed the villages and farmers that partook in the programs. Site visits were conducted from August to October 2016 by the researcher to confirm the (non) adoption the introduced CA initiatives.

Stage 4: Study selection

All studies, reports, conference proceedings, thesis, dissertations, and grey literature in the initial search relevant to the study were screened. Only those publications and articles, which best fit the criteria of CA under the established definitions were used. To ensure that the research stayed on track, the literature review took place for a period of three months (July to September 2016).

[9] USP is the largest provider of tertiary education for 12-member countries in the Pacific Island Countries (PICs).

Stage 5: Charting the data

Charting the data (Arksey and O'Malley, 2003) describes a technique of synthesizing, sifting through and sorting out the information collected. Microsoft Excel, 2010 was used to record the information gathered. The logic model and the diffusion theory were used as a framework to guide data entry (Table 2).

Stage 6: Collating, summarizing, and reporting the results

Results from the literature search are reported in a narrative format, enhanced by tables. From the literature review, the villages where the programs were established were identified and further discussions took place with the farmers involved. This verified that the CA system was introduced and to observe the extent it was practiced. Quantum Geographic Information System (QGIS) version 2.18.1 was used to map out the villages.

Village chiefs assisted with the identification of families based on the names listed in reports found. In some cases, families had migrated from the original village, which required the expansion of the search into the new villages.

Table 1: Defining the individual components of CA based on FAOs (2010) definition

Term	Definition	Source
Component 1: Minimal mechanical soil disturbance		
Zero-tillage	A way of growing crops without soil disturbance through tillage. (Tillage is defined as the changing of the condition of the soil with a tool for human benefit; tillage examples include plowing or harrowing)	(USP, 2012)
Component 2: Maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops)		
Cover crop, green manure or living mulch	A crop grown for the protection and the improvement of the soil.	(Anand, 2016)
Mulching	The retention of crop residue for soil cover.	(USP, 2012)
Component 3: Rotations or sequences and associations of crops including trees which could include nitrogen-fixing legumes		
Crop rotations	Involves the rotation of crops on a piece of land. It can also include rotation with a legume. The purpose of crop rotation is to reduce pests and diseases and to improve soil fertility to maintain the crops productive capacity.	(Nile, 1988)
Sequences, Mixed cropping, and Intercropping[10]	Mixed cropping is the growing of two or more crops on the same piece of land with or without distinct arrangement. Intercropping is a system in which two or more crops are organized in distinct arrangements.	(Tofinga, 1992)
Agroforestry (inclusive of alley cropping hedgerow cropping and Taunga[11] farming systems)	A group of land management techniques that combines crop production and forestry practices in the form of woody perennials with or without livestock. The goal is to optimize production per unit area whilst at the same time respecting the principle of sustained yield to meet households' basic needs of food and shelter.	(Tofinga: In IRETA proceedings, 1996)

[10] The term mixed cropping and intercropping has been used interchangeably in different articles and will therefore be taken to mean the same throughout this analysis. For consistency, the term mixed cropping will be used to define both terms throughout this paper.

[11] Taunga farming is defined as special arrangement which combines the production of both arable and forest tree crops simultaneously on a piece of land (Agera et al., 2010).

Table 2: Guidelines used to collect literature for the research and the CA programs

CA research-focused literature *Guidelines for data collection*						
Author, year of publication and location of study	Objective(s) of the research		Crops targeted	Indicators of soil health		Conclusion & Recommendations made
CA program-focused literature *Guidelines and framework used for data collection*						
Author, year of program implementation and location of program	Objective (s) of the program	Conclusion & recommendations made	***Inputs utilized*** a) Stakeholders (government, donor, and scientific institutions) involved in the program. b) Research (on-station, on-farm), also includes the crops targeted in the research.	***Outputs*** a) Methods of outreach e.g. publications, reports, workshops, radio programs.	***Outcomes*** a) CA adoption and number of farmers who adopted the program	***Reasons for (non) adoption*** a) Relative advantage b) Compatibility c) Complexity d) Trialability e) Observability f) Time factor g) Communication channel used within the respective social structure

2.3. Results

2.3.1. Identified Conservation Agriculture articles (published and unpublished)

The search found 233 published and unpublished papers, which covered all three CA best practices as either individual or collective components. Forty-three papers were unavailable for download from any of the respective institutions that implemented the program. The 190 remaining were evaluated to determine their relevance for the study. Based on the established definitions in Table 1 and Table 2 only 91 articles were applicable and were included as part of the analysis.

Few of the articles focused on one CA component i.e. mulching (12 percent) and mixed cropping (5 percent). Most of the articles focused on two CA components (77 percent) and three percent examined more than three CA components (Table 3).

Table 3: Focus of CA articles (published and unpublished)

Practices	Percentage	
Mulching	12	(11)
Mixed cropping	5	(5)
Agroforestry, Zero-tillage	51	(46)
Mixed cropping, Zero-tillage	11	(10)
Mulching, Zero-tillage	8	(7)
Mulching, Mixed cropping	5	(5)
Cover cropping, Zero-tillage	2	(2)
Mulching, Agroforestry, Zero-tillage	3	(3)
Mixed cropping, Cover cropping, Zero-tillage	1	(1)
Mulching, Mixed cropping, Zero-tillage	1	(1)

Number in parenthesis denotes the value of n

Most of the empirical publications (i.e. 59 percent of the publications) examined agroforestry, zero-tillage systems followed by mulching and finally mulching, zero-tillage. Similarly, most of the publications written from a theoretical perspective (i.e. 31 percent of publications) and those that provided a report (i.e. nine percent of publications) to donors focused on agroforestry, zero-tillage and intercropping, zero-tillage (Table 4).

Table 4: Breakdown of publications reporting on the results of CA research

Empirically based publications	Percentage		Theoretical and Report based publications	Percentage	
Agroforestry & Zero-tillage	27	(25)	Agroforestry & Zero-tillage	89	(81)
Mulching	20	(18)	Mixed cropping & Zero-tillage	11	(10)
Mulching & Zero-tillage	13	(12)			
Mixed cropping & Zero-tillage	11	(10)			
Mixed cropping	9	(8)			
Mulching & Mixed cropping	9	(8)			
Cover cropping & Zero-tillage	4	(4)			
Mixed cropping, Cover cropping & Zero-tillage	2	(1)			
Mulching, Agroforestry & Zero-tillage	5	(4)			
Mixed cropping, Cover cropping & Zero-tillage	2	(1)			

Number in parenthesis denotes the value of n

Most of the empirically based CA literature was published by the University of the South Pacific (USP) and the University of the South Pacific's Institute for Research, Extension, and Training in Agriculture (USP-IRETA) based in Samoa (61.41 percent). USP and USP-IRETA also published most of the reports and theoretically based CA literature (58.82 percent). FAO published a few of the empirically based publications (15.80) and PRAP published several CA reports (14.71 percent). Publishers for some CA reports were unknown (5.88 percent). Few of the empirical publications were found as published journal articles. Included in the USP publications are thesis and dissertations written to fulfill academic requirements (Table 5).

Table 5: Main publishers of CA literature materials found

Empirically based CA literature		Reports and theoretical CA literature	
Publisher	*Percentage*	*Publisher*	*Percentage*
Agroforestry Systems	1.75	Agroforestry Systems	2.94
Agronomie Tropicale	1.75	FAO	5.88
Biology and Fertility of Soils	1.75	Fixing Tree Research Reports	2.95
FAO	15.80	Government of Samoa	5.88
Government of Samoa	5.26	International Board for Soil Research Management	2.94
International Journal of Agriculture and Biology	1.75	PRAP	14.71
NFT Res reports	3.51	USP & USP-IRETA	58.82
PRAP	3.51	Unknown	5.88
Trop, Agriculture (Trinidad)	1.75		
University of Hawaii	1.75		
USP & USP-IRETA	61.41		

2.3.2. Breakdown of crops targeted in Conservation Agriculture research

Table 6 shows that CA research frequently focused on vegetables and fruit crops. Corn (*Zea mays*) was the most popular vegetable followed by tomatoes and Chinese cabbage (*Brassica chinensis*). In terms of legumes, beans were the most commonly used in research trials. Bean varieties included yardlong bean (*Vigna unguiculata* subsp. *sesquipedalis*), French bean or common bean (*Phaseolus vulgaris*), cowpeas (*Vigna unguiculata*), yam bean (*Pachyrhizus erosus*) and pigeon pea (*Cajanus cajan*). Only five research papers focused on plantation trees such as cocoa (*Theobroma cacao),* coconut (*Cocos nucifera*), mahogany (*Swietenia macrophylla*), *poumuli* (*Flueggea flexuosa*) and teak (*Tectona grandis*).

Most of the agroforestry research looked at the inclusion of a leguminous plant with taro. Such plants included trees: *Gliricidia sepium*, Dadap (*Erythrina variegate*), *Calliandra calothyrsus,* and *Albizia chinensis*. Other legumes used included mucuna (*Mucuna pruriens*) as a cover crop with taro.

2.3.3. Results of on-station research trials conducted for academic purposes by USP (1973 – 2007)

A total of 38 research trials were conducted at the USP School of Agriculture, Alafua Campus from 1973 to 2007. Table 7 shows that USP focused their research on mulching, mixed cropping, agroforestry, cover cropping and intercropping as single CA practices. In cases where more than one CA practice was investigated, these include mulching and intercropping, intercropping and zero-tillage as well as mulching, zero tillage and intercropping. Their results showed that 58 percent (n = 22) of the articles had positive yield impact. Equal proportions reported positive impacts on soil moisture content (13 percent, n = 5), weed control (13 percent, n = 5), soil nutrient impact (21 percent, n = 8), pest and disease control (seven percent, n = 3), biomass (five percent, n = 2), and economic impact (11 percent, n = 4).

Some of the articles reported negative impacts with respect to the selected CA practice. For example, three percent, (n = 1) reported negative yield impact and biomass. Eight percent, (n = 3) reported negative weed control, pest and disease control and economic impact. Thirteen percent, (n = 5) reported on negative soil nutrient impact.

Table 6: Crops frequently used in USP CA trials

Vegetables & Fruit Crops	Frequency of use (%)	Legume Crops	Frequency of use (%)	Tree Crops	Frequency of use (%)	Root & Starch Crops	Frequency of use (%)
Corn	23.08	Bean	29.73	Coconut	14.29	Taro	61.11
Tomato	15.38	*Calliandra calothyrsus*	10.81	Teak	14.29	Sweet potato	11.11
Chinese cabbage	15.38	*Gliricidia sepium*	10.81	Cocoa	14.29	Bananas	11.11
Head cabbage	7.69	*Erythrina variegate*	10.81	*Poumuli*	14.29	Giant taro	5.56
Radish	7.69	*Adenthera pavonina*	5.41	Cedar	14.29	Xanthosoma	5.56
Ginger	3.85	Dadap	5.41	*Cordia sp*.	14.29	Cassava	5.56
Zucchini	3.85	*Flemingia*	5.41	Mahogany	14.29		
Cucumber	3.85	*Leucaena*	5.41				
Okra	3.85	Peanut	5.41				
Carrot	3.85	*Pueraria phaseoloides*	2.70				
Lettuce	3.85	*Albizia chinensis*	2.70				
Green pepper	3.85	Mucuna	2.70				
Pineapple	3.85	Pigeon pea	2.70				

Table 7: CA components and their impact on each soil health indicator

CA component	Yield improvement (kg/ha)	Soil moisture content improvement (%)	Biomass increase (tons/ha)	Reduced Weed infestation (%)	Soil nutrient improvement[12]	Pest and disease control reduction (%)	Economic improvement (USD)
Agroforestry	+ (2)	N/A	N/A	+ (1)	+ (1)	N/A	+ (1)
Cover cropping	+ (1)	N/A	N/A	N/A	+ (1)	N/A	N/A
Mixed cropping	+ (4)	N/A	+ (1)	N/A	N/A	+ (2)	+ (1) - (3)
Mulching	+ (11)	+ (5)	- (1)	+ (3) - (2)	+ (5)	+ (1)	+ (1)
Mulching & Mixed cropping	+ (2) - (1)	N/A	+ (1)	N/A	N/A	- (4)	+ (1)
Mixed cropping & Zero tillage	+ (1)	N/A	N/A	+ (1)	N/A	N/A	N/A
Mulching, Mixed cropping & Zero tillage	+ (1)	N/A	N/A	- (1)	+ (1)	- (1)	N/A

[12] Soil nutrients were measured as follows: Nitrogen (%), Phosphorous, Iron, Manganese, Copper & Zinc (mg/kg), Potassium, Calcium & Magnesium (cmol/kg).

+/- Indicates that there is a positive or negative impact to soil health indicators, significant at ($p \leq 0.05$).

N/A Indicates that the results are not applicable or available for this characteristic.

2.3.4. Timeline and breakdown of Conservation Agriculture programs in Samoa

Figure 4 provides a historical look at the different CA programs introduced in Samoa since 1970. The University of the South Pacific (USP) mulching program, Government of Samoa and the Food and Agriculture Organization of the United Nations (FAO) livestock feed program, Pacific Regional Adaptation Program (PRAP) and the Australian Center for International Agricultural Research (ACIAR) soil health program.

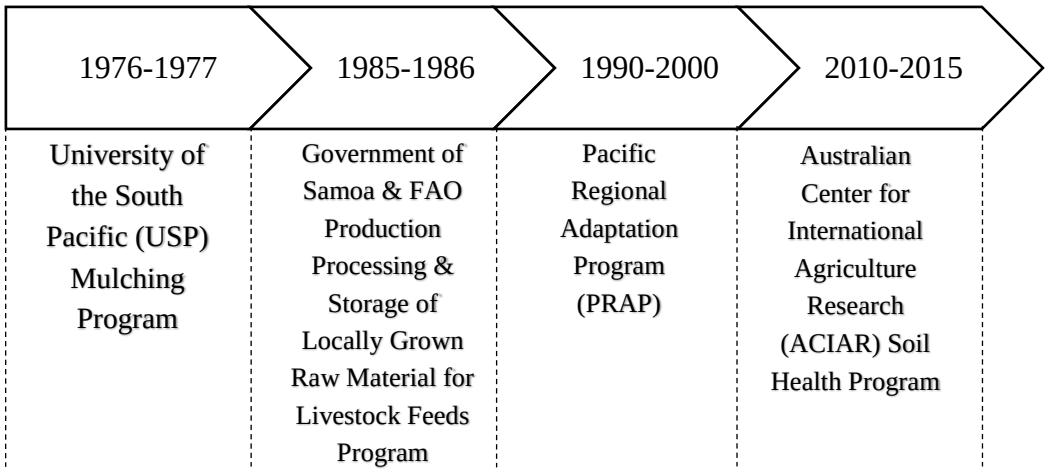

Figure 4: Timeline of introduced CA programs and institutions involved

2.3.5. Distribution of villages involved in the Conservation Agriculture programs

According to this literature review, a total of 32 villages were involved in the CA programs from 1970 – 2015; 28 villages from Upolu and four from Savaii. The reports suggest that the selection of farmers was independent of the objective of the program implemented at the time, and not all farmers were included. In some villages, only one or two farmers took part in the program (Figure 5).

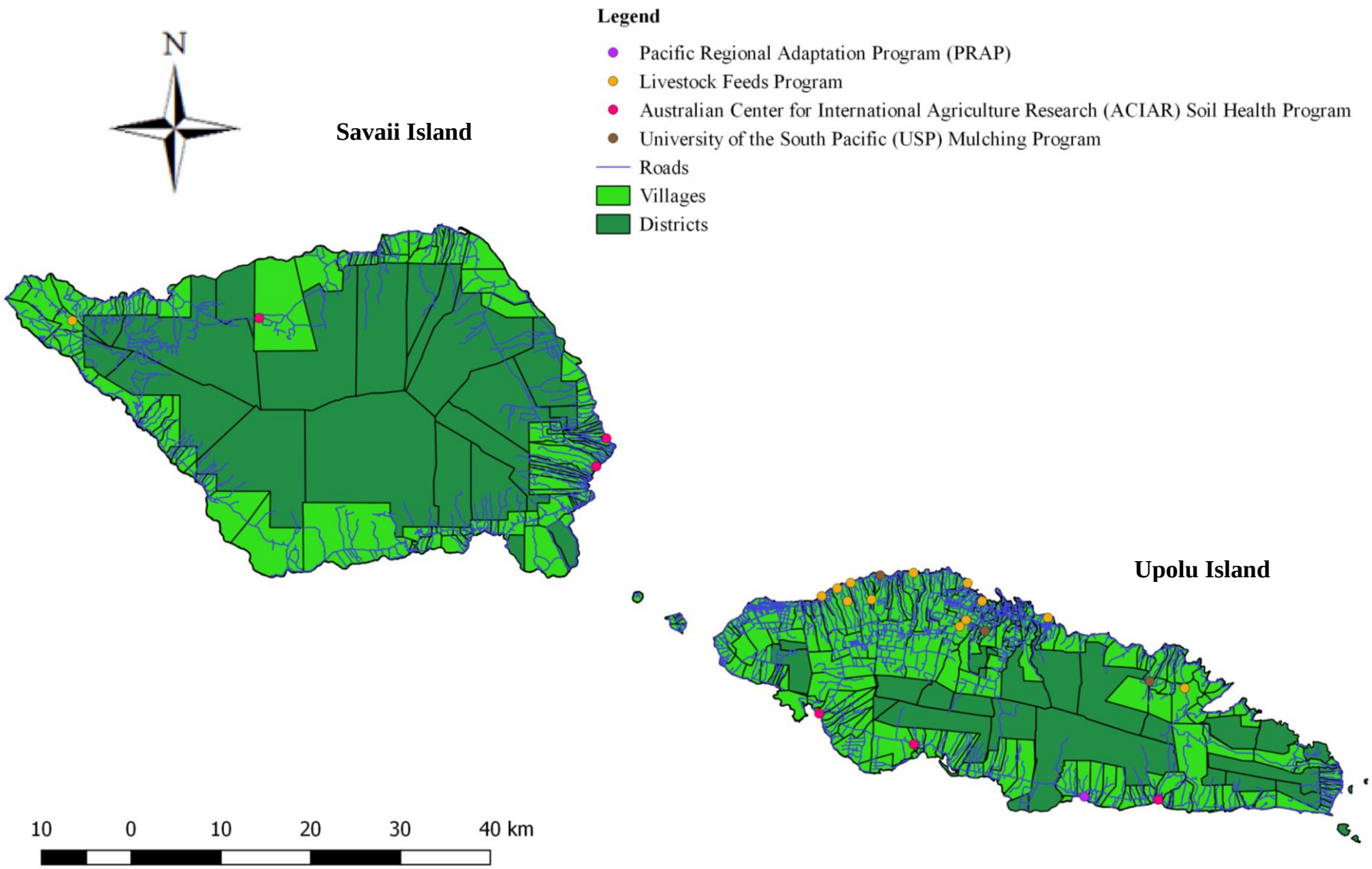

Figure 5: Areas in Samoa where CA programs were introduced from 1970 – 2015.

2.3.6. Results of the on-station and on-farm trials of four introduced Conservation Agriculture programs

Table 8 shows the results of the on-farm trials of four CA programs that were introduced from 1970 to 2015. The on-farm trials for the USP mulching program focused on mulching of pineapple (*Ananas comosus*) carried out on farmer's fields showed positive yield improvement and weed control reduction for the sun-dried coconut frond treatment. But no significant differences were detected ($p \geq 0.05$) for the wood shavings, grass cuttings and stones treatments (Table 8).

For the government of Samoa and FAO, livestock feeds program, the on-station research noted that the use of tillage was costly and therefore recommended zero-tillage for the on-farm trials. Crops such as pigeon peas (*Cajanus cajan*), cowpea (*Vigna unguiculata*), cassava (*Manihot esculenta*), and maize (*Zea mays*) and taro were planted in mixtures. The on-farm results showed positive yield and economic impact of the maize in the mixed cropping trials.

The on-farm and on-station trials for the PRAP agroforestry program showed improved yields, moisture content, improved soil fertility and reduced weeds. The system had a negative impact on labor. Similarly, the results from the ACIAR soil health program showed that that the mucuna had positive impact on taro yields, soil nutrients improvement, weed control, and economic potential.

Table 8: Results of on-station and on-farm trials for four introduced CA programs

Name of program and treatments used	Yield increase (kg/ha)	Soil moisture content retention (%)	Soil nutrient improvement[13]	Weed control reduction (%)	Labor reduction (man-hours)	Economic improvement (USD)
USP Mulching Program – a focus on pineapple						
Wood shavings sawdust	N/A	n.s.	N/A	n.s.	N/A	N/A
Grass cuttings	N/A	n.s.	N/A	n.s.	N/A	N/A
Sun dried coconut fronds	N/A	+	N/A	+	N/A	N/A
Stones	N/A	n.s.	N/A	n.s.	N/A	N/A
Government of Samoa and FAO livestock feeds program						
Mixed or intercropping of maize with taro, cassava, cowpea and or pigeon pea	+	N/A	N/A	N/A	N/A	+
PRAP – a focus on agroforestry						
Intercropping of taro with *Erythrina subumbrans* and *Gliricidia sepium*	+	+	+	+	-	N/A
ACIAR soil health program						
Mucuna as a cover crop with taro	+	+	+	N/A	N/A	+

+/- Indicates a positive or negative impact on soil improvement indicators, significant at ($p \leq 0.05$)
n.s. Results showed positive impact but were not significant ($p \geq 0.05$)
N/A Results are not available

[13] Soil nutrients were measured as follows: Nitrogen (%), Phosphorous, Iron, Manganese, Copper & Zinc (mg/kg), Potassium, Calcium & Magnesium (cmol/kg).

2.3.7. Conservation Agriculture programs and their purpose of introduction into farming communities

Table 9 shows that four research programs; USP mulching program, Government of Samoa and FAO livestock feeds program, PRAP, and ACIAR Soil Health program was introduced into Samoa from 1970 to 2010. The programs utilized CA practices to combat soil health issues to improve crop yields and farmer livelihood. The programs lasted from one year (USP mulching trials) to 10 years (PRAP). The main CA practices included mulching, cover cropping, agroforestry, and mixed cropping. Zero tillage was used for most of the on-farm trials. The crops targeted included pineapple, taro, cassava, maize, and legumes such as mucuna, pigeon pea, cowpea, *Gliricidia* and dadap (*Erythrina variegate*).

Table 10 shows the resources used, outputs as well as the outcome of each respective program. The USP mulching trial involved technical expertise from USP as well as funding. On-farm trials were conducted on two Mormon communities' lands. Farmers were actively involved in the maintenance of the trials. The main output was scientific evidence that CA worked and the publication of these results. None of the farmers in the communities adopted the CA practice of mulching their pineapple.

The livestock feeds program included FAO as the main donor. Two expatriate consultants were hired to provide training to the farmers and government officials who were part of the program. Thirteen farmers actively took part in the cultivation, and maintenance of the trials. Their lands were also used for these trials. They were also involved in processing and marketing of the harvested maize, cassava, and beans to the government feed mill. The reports that came from the program were to inform the government of the program results. There was no adoption of mixed cropping of cassava, maize, pigeon pea or cowpea by the farmers.

Initiated by USP, PRAP was modified from the original academic focused version to include 11 components[14] - each component dealing with different aspects of the program. PRAP One dealt with Farming Systems,[15] with a focus on agroforestry. A total of 12 farmers were passive on-lookers in these trials. Needs assessments were done for the farmers, but the results could not be located for this analysis. At the request of the extension officers, an agroforestry kit was designed and disseminated to the institutions and government officials who took part in the trials. A series of publications were also a product of this program. Organized agroforestry was not adopted by the farmers in Samoa.

The Soil Health Program was funded by ACIAR and managed by the Secretariat of the Pacific Community (SPC). USP was involved in the on-farm trials which used land belonging to four farmers. The farmers took on a passive role in the trials. MAF used land belonging to lead farmers for the demonstration plots and training. Two training sessions were conducted per village. No adoption of the CA practice occurred.

Table 11 shows the reasons why farmers did not adopt the introduced CA practices under the different programs. Farmers took part in the trials ranging from nine months for the Soil Health Program to four years in the PRAP trials. The duration of farmers involvement lasted for the duration of the experimental trials with no additional effort used to assist farmers to try the practice for themselves. Discussion with the farmers showed that crops introduced had no commercial outlet aside from the ones provided by the government as in the case of the livestock feeds program. PRAP systems although compatible with current practices, farmers saw that additional labor required to implement organized agroforestry. In the case of the Soil Health Program, farmers did not see any obvious benefits through the use of the practice over current ones.

[14] Farming Systems; Tissue Culture; Biometrics; Seeds and planting materials; Sweet potato variety collection and improvement; Taro beetle research; Coconut improvement; Information; Participatory Methods; Atoll agriculture; Coordination.

[15] Mucuna *(Mucuna pruriens)* was initially introduced to farmers under PRAP, but the report containing results for these trials could not be located.

Table 9: CA programs and the main purpose of introduction into farming communities

CA program	Year of implementation	CA practice	Crops targeted	Purpose of the program
USP Mulching Program	1976 - 1977	Mulching & Zero-tillage	Pineapple	To improve vegetable and fruit production through mulching
Production, Processing, & Storage of Locally Grown Raw Material for Livestock Feeds Program	1985 - 1986	Mixed cropping & Zero-tillage	Cassava, Maize, Pigeonpea, Cowpea	To increase the production of specific crops which can be used for livestock feeds
Pacific Regional Agricultural Program	1990 - 2000	Agroforestry & Zero-tillage	Taro, *Erythrina subumbrans*, *Gliricidia sepium*	PRAP one component dealt with improving farming systems with a focus on agroforestry.
ACIAR Soil Health Program	2010 - 2015	Cover cropping & Zero-tillage	Taro, Mucuna[16] (*Mucuna pruriens)*	The overall goal of this program was to address the issues with declining soil health in selected PICs

[16] Other legumes were targeted in the ACIAR Soil Health program research trials based on research conducted by Anand, (2016). However, for consistency in the analysis, this study will focus only on the trials using mucuna because this legume was also used and promoted by MAF.

Table 10: Inputs, outputs, and outcome utilized in the implementation of the programs

CA program	Inputs utilized (Stakeholder involvement and research efforts)					Outputs	Outcome of program in terms of farmer adoption
	Donors/Regional institutions	*Researchers*	*Government*	*Farmers*	Research efforts		
USP Mulching Program	USP	USP	N/A[17]	Two Mormon communities from Saleimoa & Sauniatu. The exact number of farmers involved is unknown	On-station and on-farm trials Communities' lands were utilized for trials	1) Scientific evidence of improved soil health 2) Reports on trial results	No adoption
Production, Processing, & Storage of Locally Grown Raw Material for Livestock Feeds Program	FAO funded two research consultants	Animal Nutritionist, Tropical Crop Production & Feed Manufacturing Specialist	1) Initiated program 2) Assistant personnel provided 3) Land provision for trials	13 farmers	On-station and on-farm trials Farmers lands were utilized for on-farm trials	1) Scientific evidence of improved soil health 2) Awareness about the program through radio program 3) Farmers involved in on-farm trial implementation 4) Reports to government	No adoption

[17] Not applicable for this section.

Table 10 (Continued): Inputs, outputs, and outcome utilized in the implementation of the programs

CA program	Inputs utilized (Stakeholder involvement and research efforts)					Outputs	Outcome of program in terms of farmer adoption
	Donors	*Researchers*	*Government*	*Farmers*	Research efforts		
PRAP	Funded by the European Union	1) USP Graduate Assistants 2) USP land utilized for on-station trials	N/A	12 farmers	On-station and on-farm trials Farmers lands were utilized for on-farm trials	1) Scientific evidence of improved soil health 2) Needs assessment 3) Agroforestry Kit 4) Series of publications[18]	No adoption
ACIAR Soil Health Program	1) Funded by ACIAR 2) Managed by SPC	USP Graduate Assistants & scientists conducted on-farm	MAF conducted on-farm trials	6 lead farmers	On-station and on-farm trials Farmers lands were utilized for on-farm trials	1) Scientific evidence of improved soil health 2) Demonstration plots 3) Two training sessions per village[19]	No adoption

[18] Due to the time lapse, it is unclear how many publications were produced from PRAP, but there were a series of PRAP booklets as well as reports. A needs assessment was also conducted, but the results could not be located during the time of this study.

[19] Although six villages were involved in the on-farm trials, the demonstration plots were set up and training conducted only in the villages of Siufaga, Sapapalii and Savaia.

Table 11: Reasons for the non-adoption of the introduced programs based on discussions with farmers, observations, and literature review – the diffusion theory framework

CA program	CA practices	Time	Communication channel within the respective social structure	Relative advantage	Compatibility	Observability	Complexity	Trialability
USP Mulching Program	Mulching & Zero-tillage	1) Two-year trial	Leaders from the two Mormon communities (Elders) were involved in the trials.	X	X	X	X	X
Production, Processing, & Storage of Locally Grown Raw Material for Animal Feeding	Mixed cropping & Zero-tillage	1) One-year trial 2) Training provided in the initial set up of trials.	1) Mass communication through radio talk show. 2) Farmers who heard about the program volunteered to be part of it.	X	X	X	X	X
Pacific Regional Agricultural Program	Agroforestry & Zero-tillage	1) PRAP lasted 10 years 2) Agroforestry trails lasted 4 years	Lead farmers in the village of Poutasi were part of the trials.	X	✓	X	X	X
ACIAR Soil Health Program	Cover cropping & Zero-tillage	1) USP: Nine-month trial 2) MAF: Nine-month trial 3) MAF: two training sessions provided	1) USP: Lead farmers who were also high chiefs were involved. 2) MAF: Lead farmers who were chiefs and govt. representative involved.	X	X	X	X	X

✓ Indicates that this attribute was identified as present in the outreach efforts.
X Indicates that this attribute was identified as lacking in the outreach efforts.

2.3.8. Background of extension services in Samoa[20]

Samoa's extension service comes under the mandate of the Crops Division which is one of six divisions under MAF. The Crops Division has three main sections i.e. Research, Development, and Advisory (the advisory service is referred to as the extension service and the extension professionals are referred to as extension agents throughout this paper). The government extension services are the main support service for village farmers.

The extension service in Samoa comprises of 33 extension officers. Approximately 14 are in Upolu and 19 are based in Savaii. To ensure that there is more outreach of services to the communities, MAFs extension services have agricultural stations located in the villages of Aleisa, Savaia, and Poutasi Falealili. Which are separate from the main office locations in Nuu. In the island of Savaii, MAF has an agriculture station in Salailua and Asau. The headquarters of MAF which also houses the extension officers can be found in Salelologa which is the capital of Savaii. Within each village, tunnel houses, shade houses and demonstration plots for training purposes can be found.

The role of the extension service is to be the link between the farmers and the research and the research to the farmers. MAF conducts most of their own research, and it is very rare for them to collaborate with main research institutions such as USP in the implementation of these trials. The exception to this case was the collaboration work between USP, donors and extension officers during the taro breeding program. The extension service works closely with international and regional institutions such as FAO, ACIAR, and SPC in extending specific program activities such as training, demonstrations, and on-farm trials to village farmers.

[20] Information on the extension services in Samoa was obtained from the MAF website, observations, and discussions with a key informant.

2.4. Discussion

2.4.1. Relevance of scientific Conservation Agriculture research to village farmers

For 45 years, research institutions such as USP have experimented with different CA practices in Samoa. The results from these trials have shown that CA practices were generally successful in achieving improved soil health. For example, out of the 23 publications that used yield as an indicator of improved soil health, 91 percent showed improved yield while four percent showed reduced yield. One study where grass clippings mulch improved the yield of Chinese cabbage found that weeds were reduced and therefore more nutrients were made available to the plant with the use of mulch compared to no-mulch.

Studies which reported negative improvement in the yield of the crops highlighted soil nutrient competition between plants as well as disease infestation as the main reason for the yield decline. For example, a study on tomatoes and Chinese cabbage in a mixed cropping system improved yield for Chinese cabbage in the initial stages, but a reduction in the yield of tomatoes in the later stages of the plant's growth because of competition for soil nutrients. The study also showed that mulching does not always improve yield. This is because some of the mulching materials (e.g. dadap) takes longer to decompose, and the yield benefits in the short-term are not seen (Lolohea, 2004). These examples show that CA systems are complex, with unapparent short-term benefits resulting in the slowed adoption or rejection of the whole system as reported by Shaxon, (2006) and Pannell et al., (2014).

In seven studies which used economics as an indicator of CA treatment effects. Fifty-seven percent reported positive economic impact and 43 percent reported a negative impact. The main economic savings were in reduced fertilizer use. For example, Pratap, (1996); Nauluvula, (2004); & Iranacolaivalu, (2005) reported decreased fertilizer applied to crops because of successful mulching and mixed cropping systems.

Other studies demonstrated impacts were not economical because of additional labor and in cases where crops are not compatible, additional inorganic fertilizer input is needed (Nile, 1988; Iosefa, 1997). These findings are consistent with CA studies done by Giller et al., (2009) and Umar (2012).

The results of this study show that the positive results from the research were never extended to farmers and the results remained solely for answering scientific hypothesis. The lack of outreach efforts in these studies is seen in the repetition of the type of CA practices researched on. For example, out of the 42 percent of the research that focused on mulching, more than half of them continued to use coconut fronds, *Gliricidia* and dadap materials in the trials. Furthermore, the suitability to local conditions of crops targeted in the studies is questioned e.g. maize seeds are unavailable, head cabbage seeds are expensive (1kg can costs USD 100 each). Other crops are not grown in Samoa because of taste preferences (e.g. zucchini and okra) or markets are unavailable or irregular (e.g. ginger). Moreover, the systems showed complexity in the timing of mulching, and the types of crops which can be grown together which inevitably determines the need for added costs and labor. Extending these researches to the farmers could have aided the scientists in improving the selection of appropriate crops and mulching materials to be used for further studies.

Rogers (2003; pg. 18) defines communication as "the process by which participants create and share information with one another to reach a mutual understanding". Clearly, communication gaps exist between the researchers, to the farmers which would have been better facilitated with the inclusion of extension officers. This has resulted in a repetition of CA research and questions its relevance in meeting the local farming communities' needs. Better flow of communication strategies is needed between the change agents, farmers, and researchers and vice versa to ensure more effective and farmer-focused research (FAO, 2006).

2.4.2. Introduced Conservation Agriculture programs

Four programs targeting improved livelihood by improving soil health were introduced into villages in Samoa from 1970 to 2010. None of the CA practices introduced under the programs

were adopted by the village farmers. The following section looks at each individual program and suggests the reasons for the non-adoption considering the diffusion theory put forth by Rogers (2003) and the logic model (Wholey, 1979).

2.4.2.1. University of the South Pacific (USP) mulching program

2.4.2.1.1. Inputs and outputs from the program

USP funded the on-station and on-farm trials under this program. The community members' lands were used for the trials, but no prior training was implemented. The farmers were more involved in the maintenance of the trials. The main outputs from this program were scientific evidence and reports that CA in the form of mulching using coconut fronds improved the growth of vegetables and fruits both under controlled and farmer's conditions. The literature showed no evidence that efforts were made to diffuse these practices to the farmers with the program lasting for only one year before disintegrating with no real outcomes.

2.4.2.1.2. The non-adoption of pineapple mulching in Saleimoa and Sauniatu

Despite scientific evidence that mulching pineapple improves soil health, the positive results did not transfer to convincing farmers to adopt the practice. Several reasons are suggested for this

The practice introduced under the program was not compatible with farmer's current pineapple production practices. Discussions with S.V. (personal communication, October 5, 2016) who is a chief from the village of Saleimoa established that the people in the village of Saleimoa do not grow pineapple on a large scale. He said that if a family grows pineapple, it would be less than 10 plants in their front yard. Furthermore, communities do not use mulching particularly in their vegetable gardens but prefer to clear the whole area of trees leaving the soil bare before cultivation. With the introduction of GAS[21], mulching has become even more uncommon due to infestation by the pest. Furthermore, mulching harbors the Giant African Snail (GAS) which causes severe damage to the crops. The cost of snail control is high with one 50kg bag of slug bait pellets costing US$120 (L.N., personal communication, October 6, 2016). Furthermore, the organic materials used by USP during their trials were not easily accessible in their area nor were

[21] The Giant African Snail (GAS) was introduced into Samoa in late 1994.

the materials easy to work with (L.N., personal communication, October 6, 2016). Since there is no economic potential for pineapple in the village of Saleimoa and in Sauniatu, there is also no advantage in spending time on mulching the plant.

It takes time for an idea to become either accepted or rejected by a community, and the trialability is just one important attribute to diffusing an innovation (Rogers, 2003). In this case, the research trials which lasted for one year did not give farmers the opportunity to try the practice so that they can observe the pros and cons of mulching their pineapple. Perhaps farmer observations would have provided valuable feedback to the lead farmers in the communities and in-turn the scientists on improving the trials; conceivably even a change in crops targeted would have resulted. Currently, the lead farmers in these respective Mormon communities are aware that it takes time to convince farmers about the benefits of mulching and awareness and training is an ongoing activity with their members on this practice in the implementation of their community vegetable garden activities.

2.4.2.2. Production, Processing, and Storage of Locally Grown Raw Material for Livestock Feeds Program

2.4.2.2.1. Inputs and outputs from the program

The government sought FAOs assistance to provide a crop specialist and an animal nutritionist to support activities such as crop trials, farmer and the program staff training, the set-up of the mill and the formulation of the livestock feeds. The Ministry of Agriculture (MAF) which was then known as the Department of Agriculture, Fisheries and Forests was the government agency responsible for the execution of the project. A feed mill was set up at Vaitele in Samoa[22] and the government hired a manager and provided three assistants to support the running of the mill.

On-station trials to grow cassava, pigeon pea, cowpea, and maize in pure stands and mixed stands were conducted on government land. The studies concluded that tillage was not suitable for Samoa's conditions because of the high expense and the rockiness and shallowness of the

[22] It was unclear from discussions whether this land was government land or not. However, since it was a government initiative, at this stage it can safely be assumed that the land belonged to the government.

soils. The crop specialist recommended mixed cropping and zero-tillage to be implemented for the on-farm trials. Awareness was raised by the government on the radio regarding the program. Farmers who wanted to be part of it volunteered to participate (J.N., personal communication, October 4, 2016). The program attracted 110 farmers from 57 villages with an estimated 150 acres combined between all the growers. Only 13 of these farmers participated in the mixed cropping trials. The farmer's main role in the trials was the use of their land and maintenance of the crops. Training was provided to farmers on the cultivation and maintenance of the crops during its growth. The on-farm trials were a success in increasing crop yields. This improved economic returns because of the high yields and because of crop diversity. Other CA research has reported on improved income because of crop diversity (Paudel, 2015). The program lasted for one year and despite the positive results, the farmers discontinued the growth of any of the crops introduced under the program.

2.4.2.2.2. The non-adoption of the livestock feeds program by the village farmers

Several reasons are suggested for the failure of the program. The crops and the CA system introduced was not compatible with current practices, it was complex and there was no relative advantage of growing the introduced crops. Furthermore, farmers did not see any benefits in the system and with no proper consultation of farmers' needs prior to the implementation of the program and during its course, the program failed.

Rogers (2003) highlights that the complexity of an innovation reduces its likelihood of being adopted. Although the practice of mixed cropping is compatible with local farming practices, cassava, beans, and corn are only grown as subsistence crops when the village farmers acquire seeds. Therefore, growing these crops in a mixed cropping arrangement on a large scale is complex for the farmers. Farmers need to understand the best cultivation strategies, the maintenance, harvesting and post-harvest aspects of the introduced crops. The project ended up with 13 farmers willing to conduct mixed cropping of these crops. This is 12 percent of the number of farmers who showed interest. The rest of the farmers opted to use monocropping of cassava or corn or the legumes. Andersson and D'Souza, (2013) & Shaxson, (2006) also reported that the complexity of CA systems can slow or stall its adoption as seen in this case.

There was no relative advantage of growing the crops to the farmers. Children of the original farmers who participated in the initiative from their observations said that the lack of and inconsistent markets were contributing factors to the discontinuation of the growth of the crops by their parents and by them (A.T. personal communication, October 5, 2016). The only place that farmers could sell their harvest too was the feed mill, there were no other available market outlets for the introduced crops and when the system failed farmers discontinued growing the crops. "Once the factory closed the cassava which we harvested rotted because we had no other markets available. Our father struggled to pay back the debt he owed to the development bank" (L.S., personal communication, September 30, 2016). P.T reiterated this concern "we no longer have the cassava and corn varieties given during the trials. When the program closed, we harvested the corn and sold it to the school in the village because that was the only option we had" (P.T., personal communication, October 11, 2016).

The Minister of Agriculture from the time of program said that from the government's perspective, the program was uneconomical because it was difficult to convince the farmers to supply the mill (J.N., personal communication, October 4, 2016). He said that the farmers lacked confidence in the program and the government's ability to implement it successfully. The government outsourced the feed mill to someone with expertise in the area, but the mill continued to remain uneconomical and eventually closed. "The farmers were fed-up with the mill" (J.N. personal communication, October 4, 2016). There was no advantage of continuing with the program because of the constant changes and lack of proper planning. "Most of the time when we brought our products to be weighed we had to wait for hours before we received our money. The money received did not compensate for the labor put into processing the products". (L.S., personal communication, September 30, 2016). Essentially, farmers did not see any advantage in continuing to pursue growing crops with no other market outlets, high labor requirements and with little monetary returns.

The lack of proper planning by the government and the donors and proper consultation of the villagers was the biggest hindrance to this program. A top-down approach was used by the government with the communities. It is unclear from the reports whether extension agents were involved during the implementation of the program, but, it was apparent that there was no proper

monitoring put in place for farmers to provide their concerns during the implementation of the trials and marketing of the crops. Farmers implemented the trials and supplied the feed mill based on guidance by the government and consultants.

Farmers were unsatisfied with the program because of the difficulties that they faced such as labor intensity, lack of markets and no support system. This is reflected in discussion with one of the farmers. S.L. is a subsistence farmer from a rural village on the island of Upolu. He relies on cocoa and coconuts for his living and takes his goods to the town market on a weekly basis. His statement illustrates the frustration that farmers felt at the breakdown between the government and the farmers regarding the introduced programs "My father was part of the livestock feeds program. To this day, I do not know where all the cassava varieties given to my father are. The biggest problem with these programs is that the government does not understand the farmers. It is important for the government and those people carrying out the programs to come down and talk to us farmers" (S.L., personal communication, October 11, 2016).

Effective communication needs to follow feedback loops from all parties concerned in the implementation of the program (FAO, 2006). For this program, although farmers were given the opportunity to be involved in the trials, their involvement was passive, and they were not given the chance to voice their concerns on the benefits and limitations of the system. The lack of consultation with farmers resulted in a program that failed to address their needs and eventually left the farmers stranded with no available markets for their products and no form of risk insurance to support them.

2.4.2.3. Pacific Regional Adaptation Program

2.4.2.3.1. Inputs and outputs from the program

The Pacific Regional Adaptation Program (PRAP) began working in Samoa in the 1990s until 2000. CA research under this program took place for a period of four years. The results from this study showed that the physical soil properties (soil bulk density, water holding capacity and lower soil temperature) were improved under the alley system. Positive impact was also found from nutrient input into the soil by either tree species, particularly the return of Nitrogen,

Phosphorus, and Potassium with *A. Chinensis*. This species also produced higher tree biomass from the pruning's making it good mulch material. Weeds were reduced with the use of alley cropping relative to the control (no trees) (PRAP Working Paper No 96-1, 1996; Iosefa, 1997). Work by Iosefa (1997), determined that labor requirements were largest for coppicing of the trees in the alley system.

The initiation of the agroforestry trials came out from observed farmers' practices on the use of the *Erythrina* with taro. Farmers' practices were trialed in an arranged form to identify its soil health contribution (S.R., personal communication, October 26, 2016). The program also developed an agroforestry kit at the request of extension officers and a series of publications on the program's success stories and lessons learned. Despite more involvement by the communities as well as the extension agents in this program, there was still no adoption of the introduced agroforestry practice by village farmers.

2.4.2.3.2. The non-adoption of the Conservation Agriculture practice under Pacific Regional Adaptation Program

Although the introduction of planting dadap and taro is compatible with local taro planting practices, coppicing proved to be labor intensive. The data showed that 155 more-man hours per acre were required for tree maintenance through coppicing under the dadap agroforestry compared to the control treatment. Other studies have indicated that additional labor requirements influence farmer's decision to adopt or reject CA practices (Lai et al., 2012; Halbrendt, 2014). From this perspective, it had a comparative disadvantage over current farmers' practices. Furthermore, the system is arguably complex compared to the current practices. This is because farmers must adapt a new way of planting dadap with their taro. Farmers would randomly plant dadap within their taro patch; the new arrangement requires farmers to consider new spacing arrangements for their taro and dadap cultivation.

Farmers were unable to try the systems themselves and were only passive on-lookers; they were not given the opportunity to observe the main benefits and limitations so that they can formulate their opinion about the introduced practice. Community involvement as well the communication of the research over time would have perhaps aided in adapting the system to suit the needs of

the local communities. Trialing and observations are important because it allows farmers to seek and process information to help farmers reduce their uncertainty about the innovation (Rogers, 2003). M.I. (personal communication, September 21, 2016) reiterates this statement by saying that USP should have continued the research that PRAP started, and farmers should have been involved more in the study. They stopped the research after four years and they noticed some positive results in yields, but their results were not enough to convince farmers to adopt the system.

The revival of the alley cropping research with improved consultation with farmers and extension officers is perhaps needed as this is a system which has shown promising results from a scientific standpoint, and it is compatible with current farming practices.

2.4.2.4. Australian Center for International Agriculture Research Soil Health Program

2.4.2.4.1. Inputs and outputs from the program

Some of the main resources used to create awareness about mucuna were through on-farm research trials carried out by USP on farmer's fields. No collaboration occurred between the ministry and USP researchers during the trials; instead, a lead farmer from Siufaga approached the MAF for support on the use of the mucuna as they were not sure about its purpose (T.T., personal communication, November 20, 2016). MAF took on the initiative to train farmers promoted the use of mucuna through demonstration plots from 2014 to 2015 in Siufaga, Sapapalii, and Savaia. However, these trials lasted for nine months which gave the farmers little time to trial the plant for themselves or to observe any benefits of the mucuna over current practices. No adoption of mucuna occurred.

2.4.2.4.2. The non-adoption of the Conservation Agriculture practice under the Pacific Regional Adaptation Program

Non-adoption of the mucuna occurred because farmers were not convinced about its benefits. "I was not convinced by the difference between taro yields from the mucuna to the taro in my plantation. The corm size of the taro in my plantation was the same as the corm from the mucuna plots harvested" (U.P., personal communication, October 15, 2016). Observability is an

important attribute which needs to be considered by the intended adopter to decide whether to accept or reject the innovation (Rogers, 2003). In this case, farmers did not perceive that yields differed from either system.

Although the lead farmers in the respective village's lands were used, they were not directly involved in the trials. "Perhaps if we were involved from the beginning of the USP trials and MAF demonstrations we would have had a better idea about the plant and its potential benefit as a cover crop." (V. M. personal communication, October 14, 2016). The demonstration plots only involved lead farmers, and aside from the village of Savaia, most village members were not included in the training provided by MAF. Only the lead farmer's relatives and close friends were included. "We heard about the program, but we were not involved, our lead farmer worked with MAF. Most of the agriculture programs come from the lead farmer's family" (V.F., personal communication, October 15, 2016). According to Rogers (2003), the use of lead farmers will not always result in the adoption of an innovation. This is because they have their own network within their community which they use and exclude other village members as seen in the case of the mucuna.

T.T. (personal communication, November 20, 2016), acknowledges the time constraint of the system, and therefore the need to use lead farmers. This is because the extension officers in Samoa are challenged by the lack of human capacity and resources to work on any one program for a long period of time.

2.5. Conclusion

The CA on-station and on-farm trials showed positive soil health impacts particularly for yield increase, soil moisture content improvement, lower soil temperature and increased nutrient content for some of the studies. However, the scientific benefits did not result in the adoption of the systems. Several reasons were seen for this; the non-compatibility of some crops in mixed cropping systems, labor intensity in the agroforestry systems and increased GAS and weed infestation due to mulching were identified as challenges associated with using these practices. These results show the complexity of CA systems. The study also showed that there are no

efforts by the scientists to link research to extension officers and to farmers. In fact, there are no communication strategies between the three players. Communication efforts are needed to help improve the relevance and effectiveness of the CA research to farmers' situations with farmers need driving the research direction.

Four implemented programs failed because farmers were not consulted from the beginning and during the implementation of the program. This resulted in the introduced CA programs not being compatible, had no advantage over the current systems and was too complex. Farmers were not given the opportunity to trial these practices for themselves so that they can observe the limitations and benefits of the systems. Although lead farmers in the respective villages were involved, their involvement was passive, because the researchers and extension officers took a top-down approach to the implementation of the trials. Furthermore, lead farmers tended to involve only those within their network in the implementation of the trials. Therefore, other village members were excluded from the trials.

It is recommended that researchers, extension officers, and farmers work together on the implementation of the programs starting with a needs assessment for farmers. Farmers need to be the driver of research related to CA work in Samoa. Farmers, extension officers, and researchers need to work together on the programs from the beginning to the end. Farmers need to be given the time to observe the benefits and limitations of these systems over time and over current systems and be given opportunities to provide feedback to the extension officers and the researchers.

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Chapter 3

Comparing current practices over introduced Conservation Agriculture (CA) of mucuna (*Mucuna pruriens*) as a cover crop in the villages of Siufaga and Savaia in Samoa

Abstract

With village farmers in Samoa failing to adopt introduced CA practices this study was initiated to understand some of the reasons why. This study compared the relative advantage, compatibility, and complexity of an introduced Conservation Agriculture (CA) practice over current practices. The study used the case of (*Mucuna pruriens*) as a cover crop and compared its benefits and costs over current taro cultivation practices in Samoa. The study also identified the communication channels used to extend the introduced CA practice of mucuna to village farmers.

The study found that farmers in Samoa already practice CA and this system has sustained their taro production systems for many generations. Also, the introduction of Taro Leaf Blight in Samoa gave the farmers enough time to replenish lost nutrients prior to the TLB era. Hence farmers do not see the need to use mucuna as a cover crop. Furthermore, mucuna as a cover crop is new and did not provide any relative advantage, was not compatible with current taro cultivation methods and beliefs of local village farmers. The system was also too complex and would require farmers to change their cultivation methods to implement the system successfully. Furthermore, the study found that the village council was more effective in raising awareness about the mucuna compared to the use of lead farmers. The study recommends that extension officers involve the village council in the programs to ensure that more village farmers become involved. Also, more time is needed in the implementation of introduced CA practices rather than the nine-month trial period used in the training conducted. This is to give farmers time to observe and trial the practices themselves to reduce uncertainty about the use of the plant.

3.1. Introduction

The term Conservation Agriculture (CA) encompasses three key farming practices (1) minimal mechanical soil disturbance (i.e. zero-tillage and direct seeding); (2) maintenance of a mulch of carbon-rich organic matter covering and feeding the soil and (3) rotations or sequences and associations of crops including trees which could include nitrogen-fixing legumes (FAO, 2010). The Food and Agriculture Organization of the United Nations (FAO) actively promotes CA worldwide particularly, to small-holder farmers in the developing world (Kassam et al., 2015). CA can be adapted to a variety of agroecological zones and farming systems and has the potential to improve farmers' livelihood through improved soil health (FAO, 2010; Pradhan, 2015).

Although CA has gained momentum worldwide with an estimated 157 M ha now being affected by one or more CA practice (Dumanski et al., 2006; FAO, 2017), small-holder farmers have either been slow or unwilling to adopt introduced CA practices (Giller et al., 2009; Corbeels et al., 2014). Knowler & Bradshaw (2007) and Pannell et al., (2006), suggest that the barriers to the adoption of CA are context and site-specific. However, farmers can be persuaded to adopt a practice if its relative advantage compared to current practices can be observed (Rogers, 2003; Pannell et al., 2006; Greiner et al., 2009). Other attributes of CA practices such as their compatibility with current beliefs, experiences and practices; the complexity compared to current practices; the ability of potential adopters to try each practice themselves; and the ability to observe their benefits can help reduce the uncertainty surrounding their use and facilitate their adoption (Bohlen et al., 1961; Rogers, 2003).

With taro (*Colocasia esculenta*) production areas expanding in Samoa to meet the domestic and overseas demand, local, regional and international institutions are concerned about the future decline of soil fertility (ACIAR Proposal, 2009; Agriculture Sector Plan, 2011-2015). Mucuna (*Mucuna pruriens*) was introduced as a cover crop by Australian Center for International Agriculture Research (ACIAR) Soil Health Program in six villages to assist farmers with soil health concerns caused by reduced fallow periods and intensive taro cultivation. Aside from its potential benefits to soil health (Anand, 2016), mucuna was seen by the Ministry of Agriculture

of Fisheries (MAF) as a way to reduce costly herbicide use in taro production by local farmers. The ACIAR Soil Health Program ran from 2010 to 2015 and upon its conclusion, farmers discontinued the use of the mucuna.

The objective of this study was to understand why village farmers did not adopt the introduced CA practice of mucuna as a cover crop by comparing this introduced practice over the current ones. The study investigated the attributes of the mucuna as a cover crop and compared this with current production practices in order to identify specific issues that resulted in its non-adoption. Data were collected using in-depth interviews with farmers and key informants, and participant observations. Understanding the limitations and the benefits of the introduced practice over existing ones will aid in future research and outreach efforts aimed at encouraging the adoption of mucuna and other similar introduced CA practices at the village level in Samoa.

3.2. Methodology

3.2.1. Background of the study sites

Siufaga is located on the eastern coast of the big island of Savaii, Samoa. It is approximately ten kilometers from the wharf in the island's capital, Salelologa. Siufaga is one of five sub-villages within the district of Faga. Other sub-villages in Faga include; Sapini, Luua, Malae, and Salimu. Savaia is located on the south-west coast on the island of Upolu. By comparison, Savaia is the more developed of the two villages because it is placed in Upolu which is considered to be more developed in terms of education, job and market opportunities (Figure 7 shows the location of the study sites).

The two villages are examples of a typical Samoan village i.e. their political and social system is based on the extended family (*'aiga*) (Paulson & Rogers, 1997). One main feature in a Samoan village is the village council (*fono*), made up of all the chiefs, high chiefs, and talking chiefs, of the village. The village council is responsible for the overall welfare of village members, by regulating village life, settling disputes and distribution and control of village resources such as land (Paulson, 1994). Each chief is responsible for the welfare of their *'aiga*, providing

oversight on family welfare including the distribution of family land to members for cultivation. The *'aiga* serve their chief in the form of service (*tautua*). The *'aiga* is comprised of separate households and is defined in this study as one or more persons who live together and have their meals together (Agriculture Census, 2015).

Semi-subsistence agriculture and fishing are prevalent, playing an important role in the village economy of both villages. Although a variety of crops are grown by the village farmers, taro is the most important, not only is it the main staple crop, but it holds cultural value for the local people (O'Meara, 1990). Essentially, it is this cultural significance which has resulted in the development of a lucrative market for the crop based on the demand from Samoans living overseas (Retrieved, January 18, 2018, FAO). Hence, taro is grown not only for home consumption but as the main income generator for village farmers (Paulson, 1994). Farmers refer to their taro patches as plantations (*maumaga*) whether less than an acre or more than 10 acres. Males do plantation work, while females are involved in weeding, crop maintenance and marketing of the products (Schoeffel & Meleisea-Ainuu, 2016).

3.2.2. Socio-demographics of the selected villages

Table 12 shows the socio-demographics of Siufaga, Savaia, and all other villages. According to the 2011 Census, the population of Siufaga is 561 people with 79 households and 44 households (56 percent of the available households) were interviewed for this research. Thirty-four percent of the respondents completed their education at the primary level, 64 percent at the secondary level, and five percent at the tertiary level. Both males and females were interviewed, in roughly equal proportions with 52 percent males and 48 percent females. Although the 2011 Census records no female farmers in Siufaga, observations showed that females significantly support farming activities, including weeding, planting, and marketing. Plantation work in the village is typically family oriented; therefore, gaining both the men's and the women's perspectives for mucuna's non-adoption was important to this study. The mean age of the females interviewed was 46.13 and 49.19 for males. The average household size based on the 2011 Census is seven. For this study, the number in a household ranged between three and 14 with an average of six.

In Savaia, the 2011 Census records the population as 399 with a total of 58 households. Thirty-seven households from Savaia were interviewed, which is around 64 percent of the total households. Similar to Siufaga, interviews took place in farmers' fields, the village market and as farmers rested in their houses. Seventy percent of the respondents were male and 30 percent were females. Females in the household referred the researcher to the males in the family as they were more familiar with the mucuna. In cases where both the females and the males of the household were interviewed; the male was recorded as the main interviewee. Also, more males were involved in selling taro. These reasons increased the number of male respondents. The mean age for males was 49.58 and females were 49.73, while the mean age of all the respondents was 49.62. The range for a household size was three to 13 with an average household size of seven. This is similar to the average household size recorded in the 2011 Census of 6.87.

Spot checks were carried out in the other villages of Aopo, Sapapalii, Salani, and Safaatoa where mucuna was introduced by MAF or USP. A total of 26 farmers were interviewed from these villages until a "saturation point"[23] was reached. The only village whose responses slightly differed from the rest was Aopo. Famers in this area do not use any form of herbicide to control weeds, depending instead on their labor for clearing and cultivation of taro. Table 12 shows the socio-demographics of the study sites.

[23] Saturation point in this context is defined as that point in which no new information is received whilst conducting interviews. Farmers were bringing up the same issues and concerns regarding the use of the mucuna. They were also giving similar information regarding their farming practices, and the constraints that they faced.

Table 12: Socio-demographics of study sites

	Siufaga	n	Savaia	n	All other villages	n	Data for Samoa[24]
Educational level							
Primary	31%	14	17%	6	42%	11	60%
Secondary	52%	23	70%	26	58%	25	51%
Tertiary	48%	21	30%	11	0%	1	49%
Sex of respondents							
Male	52.5%	42	56.3%	45	96%	25	51%
Female	47.5%	38	43.8%	35	4%	1	49%
Age of respondents							
Mean age male	46.13	23 *(SD = 13.10)*	49.58	26 *(SD = 13.90)*	46.36	25 *(SD = 11.99)*	24.2
Mean age female	49.19	21 *(SD = 11.59)*	49.73	11 *(SD = 16.87)*	60.00	1 *(SD = N/A)*	23.7
Mean age per respondent	47.59	44 *(SD = 12.36)*	49.62	37 *(SD = 14.60)*	46.88	26 *(SD = 12.05)*	23.9
Mean number per household	6.25	44 *(SD = 2.71)*	7.14	37 *(SD = 2.58)*	6.08	26 *(SD = 2.50)*	7
Farming duration (years)	22.02	44 *(SD = 14.80)*	18.49	37 *(SD = 12.62)*	26.04	26 *(SD = 13.12)*	N/A

SD: Standard deviation
N/A: Data is unavailable

[24] Source of data: Samoa Bureau of Statistics, 2017.

Table 13 shows the responsibility of respondents in their respective villages. In Siufaga, untitled males comprised the majority of the sample at 27 percent. Chiefs, including high chiefs and talking chiefs, covered 25 percent of the respondents with wives of untitled males and wives of talking chiefs making up 16 percent and 23 percent of the respondents respectively. The other category, comprising nine percent of the respondents, included those who worked for the private sector or the government, but also held chiefly titles and resided in the village.

In Savaia, the majority of respondents, 46 percent, were untitled males with 24 percent of the respondents being talking chiefs and high chiefs. The females were the wives of untitled males and wives of talking chiefs at 22 percent. Eight percent of the respondents had a responsibility in the village and they also worked for the government, private sector or ran their own business.

In all other villages, 77 percent were chiefs, followed by those who also held chiefly roles in the village and worked for either the government of or private enterprise (12 percent). Only eight percent of the respondents were untitled males. In this case, village members referred the researcher to chiefs of the households for an interview. In cases where more than one member of the family was present, including the chief of the family, the chief's name would be noted as the main person being interviewed. However, this is not to say that other family members' opinions were not included in the interview. The chiefs in the family were knowledgeable about the plantations and could provide detailed information during the in-depth discussions.

Table 13: Responsibility in the village

Responsibility	Siufaga village		Savaia village		All other villages	
	(%)		(%)		(%)	
Untitled male	27	(12)	46	(17)	8	(2)
Wife of an untitled male	16	(7)	11	(4)	*	*
Wife of talking chief	23	(10)	11	(4)	4	(1)
Talking chief	7	(3)	8	(3)	62	(16)
High chief	18	(8)	16	(6)	15	(4)
Other	9	(4)	8	(3)	12	(3)

Note: Number in parenthesis denotes the value of n
* Indicates that data was not collected for this variable

3.2.3. Data collection methods

The soil health program introduced mucuna as a cover crop into six villages on the island of Upolu and Savaii using on-farm trials conducted by a USP Research Assistant in the villages of Safaatoa, Salani, Aopo, and Siufaga. The trials lasted for nine months, which is the duration of the taro plants production cycle. In the villages of Savaia, Siufaga, and Sapapalii, MAF set up demonstration plots on customary lands belonging to lead farmers who were chiefs and provided training on the use of mucuna. These lead farmers were members of farmers associations, which consisted of relatives and friends. The plots consisted of mucuna planted as a fallow crop and mucuna mixed cropped with taro. The trials and the training remained for the duration of the taro's growth cycle which is nine months with two training sessions being conducted: (1) planting of taro and mucuna (2) their maintenance. Harvesting of the taro was an opportunity for MAF to take yield data and for farmers to see yield differences (if any).

The villages of Siufaga and Savaia were selected for further interviews. Siufaga was selected because the farmers have the most problems with soil health (Anand, 2016) compared to the other villages. Savaia was selected because farmers were expanding taro production for the domestic and export market. Some farmers from Savaia have indicated that their village was one of the first to start exporting Taro Leaf Blight (TLB) resistant taro varieties. In both cases, mucuna appeared to hold potential as a CA cover crop. Aopo was initially included because these farmers have laws established in their village banning any use of herbicide or chemical fertilizers making them one of a few organic villages in Samoa. However, because of heavy rain and flooding of access roads to the village at the time of the study, Aopo was inaccessible and eventually excluded (Figure 6).

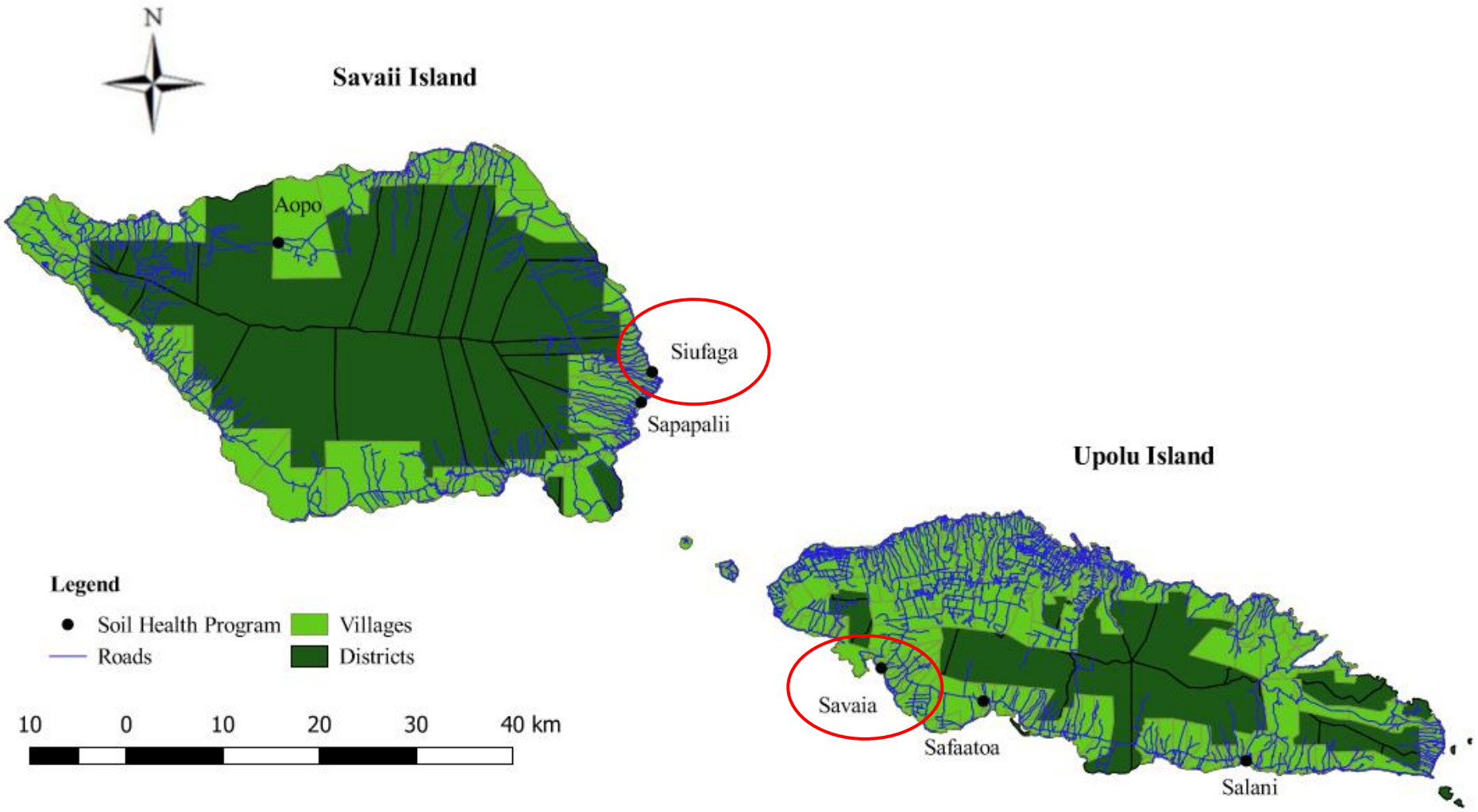

Figure 6: Villages where mucuna was introduced through the Soil Health Program. The highlighted areas show the study sites.

3.2.3.1. In-depth interviews

In-depth interviews require that the researcher take the time to listen to the respondent as they express their ideas and feelings (Bernard, 2002). A list of questions (Table 14) provided guidance during the discussions with the farmers; however, discussions that ventured into other aspects of the farmer's issues occurred and were recorded.

In total, 107 in-depth interviews were conducted with the village farmers over a period of seven months (December 2016 to July 2017). Forty-four interviews took place in Siufaga and 37 in Savaia. Spot checks, to ensure that responses from these villages were consistent with those from other study sites, were conducted with 26 in-depth interviews with farmers in all other villages (Sapapalii, Aopo, Safaatoa, and Salani) where mucuna was also introduced. The *pulenuu* and the high chief in the area recommended the farmers selected.

Prior to conducting research in Samoa, approval was obtained from the Institutional Review Board (IRB) of the University of Hawaii. Within the selected villages, support was sought from the respective village high chief (*Sa'o o le nuu*) and *pulenuu*. An introductory letter was given to them as a written record that the researchers' respective university approved the study. Seeking the approval of the prominent village members ensured that other members of the community participated in the study. The chief and *pulenuu* informed other community members of the purpose of the study. In cases where village farmers were not aware of the research, a mention of the *pulenuu* and the high chief and their approval of the study served as confirmation. The villagers were receptive to participating and directed the researcher to other farmers within the village.

Table 14: Guiding questions during the discussions

	Question guidelines
1	What are some of the CA programs that you are aware of?
2	What are the benefits and limitations of these CA programs?
3	What are your thoughts on the introduction of the mucuna CA program?
4	What is your main objective with respect to the mucuna CA program?
5	What are some limitations and benefits of the mucuna CA system?
6	What support do you need to improve the use of mucuna CA in your area?
7	How do you compare the introduced mucuna over your current practices?

At the beginning of the discussion with the respondent, the purpose of the study was explained to them. Their verbal approval was gained before beginning the interview. Notes were taken and a recorder was used to record the whole discussion. The household heads were sought out for interviews. However, during some the interviews, other family members also took part in the discussions and this was counted as one interview. The involvement of the family members during the conversation gave an improved understanding of the allocation of resources and relationships between family members. In some cases, the farmer specifically asked not to record certain information. In this situation, the recorder was turned off and then turned on again, with the farmer's approval. Although the information was excluded from the analysis, it was important in understanding the individual farmers' views on the introduction of the CA program in their village.

3.2.3.2. Key informants

Eight key informant interviews were utilized during the study. Key informants included consultants, village opinion leaders, extension officers, and scientists involved with CA work in Samoa. Discussions with key informants guided question development and provided the context for the introduction of CA programs. Clarity on the introduction of mucuna and the people involved in these programs was also sought from the key informants. Furthermore, key informants, especially the village opinion leaders' including high chiefs, talking chiefs, and the *pulenuu* views on certain cultural protocols were utilized.

3.2.3.3. Participant observation

This study employed Bernard's (2002) technique described as a participant observer and what Emerson (1995) defines as "getting into place". Using this method produces a holistic understanding of the issues faced by the farmers daily, particularly in relation to their cultural, family and village obligations. It also gave a sense of the issues farmers meet in their daily agricultural work and specifically with the use of the mucuna.

3.2.3.4. Focus group discussions

Five focus group discussions took place with two in Siufaga, two in Savaia and one in Sapapalii. The focus group discussions in Siufaga were more formal with the women and males being separated and informed in advance about the sessions. The focus group discussions in Savaia occurred more informally with the male farmers who were resting in the village market building after their morning plantation work. Similarly, focus group discussions with the females took place in their meeting house as they waited for their children to return from school. In Sapapalii the focus group discussion occurred by chance with farmers selling their taro and with those resting in the market house. These discussions provided insight into farmer's uncertainty about the mucuna and to confirm the results of the in-depth discussions regarding their reasons for not adopting mucuna as a cover crop.

3.2.4. Data analysis

The interviews were conducted in the Samoan language. On average one interview took 43 minutes. The shortest interview was nine minutes and the longest was two-and-a-half hours. After a day's discussion with the farmers, the interviews would be replayed and the discussion transcribed and translated into the English language by the main researcher. The descriptive and thematic analysis was utilized in this study. Thematic analysis involves familiarizing oneself with the data through immersion, sorting out, categorizing sections of texts as well as sayings into common themes. While sorting out, evolving patterns were grouped into relevant and/or common themes and then coded. Descriptive statistical analyses were conducted using the Statistical Package for Social Scientists (SPSS v 23).

3.3. Results

3.3.1. Land area available and under cultivation

All the farmers interviewed operated under the customary land tenure system which was expected since 81 percent of the land in Samoa is under this system (Agriculture Sector Plan, 2011-2015). Farmers were asked to provide details on land area belonging only to the household that was available to them, how much land was currently being utilized for growing crops and specifically for their taro plantations. In some situations, farmers could use land belonging to their church or village if it were available, however, because some farmers did not have access to church or village land, this study focused only on land belonging to the household to ensure consistency in the responses.

Twenty-seven percent of farmers in Siufaga, 35 percent in Savaia and eight percent in all other villages were unaware of the total land area available to them for farming. When asked about the area under cultivation, all Siufaga farmers were aware of this land area. This is because farmers from Siufaga had smaller land areas compared to farmers from Savaia and all other villages. This made it easier for them to estimate how much land area was available for cultivation. For Savaia, 54 percent of farmers were unsure of the land area under cultivation, and 12 percent for all other villages were unsure.

In Siufaga, the average land area available per household was 5.66 acres, 2.95 acres was under cultivation 0.97 acres planted with taro. In Savaia, 39.54 acres was the average land area available per household, 20.22 acres were cultivated with crops and 12.30 acres was planted with taro. For all other villages, 65.72 acres was the land area available per household, 18.08 acres was utilized for crops and 8.0 acres was cultivated with taro (Table 15). Due to limited land areas available in Siufaga, they cultivated less land with taro compared to all other villages. Siufaga farmers grew enough for home consumption and the surplus would be sold locally or exported for income.

Table 15: Land area available and under cultivation

Village	Average land area per household (acres)	Percentage of people unsure about total land area	Average land area under cultivation (acres)	Percentage of people unsure about total land area under cultivation	Average land area under taro cultivation (acres)	Percentage of people unsure of land area under taro cultivation
Siufaga, Savaii	5.66	27 (12)	2.95	0 (0)	0.97	0 (0)
Savaia, Upolu	39.54	35 (13)	20.22	54 (20)	12.30	19 (7)
All other villages	65.72	8 (8)	18.08	12 (3)	13.17	8 (2)

Note: Number in parenthesis denotes the value of n

3.3.2. Current farming practices

3.3.2.1. Component 1: Minimal mechanical soil disturbance

Village farmers in Samoa use zero-tillage. A simple metal pole with a sharp pointed head (*oso*) is used for taro cultivation. Taro is planted by plunging the *oso* into the soil a few times until the hole is wide and deep enough for the taro top. No village farmer in Siufaga, Savaia or all other villages had or could afford to hire a plow. Tilling is non-existent in Samoa at the village levels.

Discussion with a group of male farmers in the villages of Siufaga and Savaia took place around their tilling practices. Farmers in Siufaga were not familiar with tilling and its implications and they said that these types of farming are non-existent in their village. They also heard that the Adventist Development and Relief Agency (ADRA) is considering introducing a plow for farmers in their village. The farmers were uncertain about its positive or negative impacts. However, one farmer noted that he had attended training provided by MAF and remembered being taught that tilling the soil would harm beneficial soil microorganisms such as earthworms and it would also destroy soil structure. Essentially, farmers see that their current practice of zero-tillage are sufficient for their purposes and that tilling is unfamiliar, thus they are doubtful of its consequences and could be harmful to their soil. Savaia farmers pointed out that only one person who is a commercial farmer in their village could afford to hire the government tractor to till his land. Discussion with this commercial farmer who is a lead farmer in the village indicated that he is just exploring with the idea of tilling for his sweet potato patch. He further added that

his family's land was used for the mucuna trials and the plant become unmanageable so he also hired the tractor to eliminate the mucuna by tilling it into his soil as a green manure.

3.3.2.2. Component 2: Maintenance of a mulch of carbon-rich organic matter covering and feeding the soil (e.g. straw and/or other crop residues including cover crops)

The first step in taro cultivation is the *lafo* or land clearing either by herbicide or by hand using a machete to slash the weeds. Farmers in Siufaga used a combination of hand clearing and herbicide to clear their land for taro cultivation. In Savaia, farmers relied more on herbicide for land clearing and weeding because they had larger land areas.

During the growth of the taro, weeding occurs twice either by hand or with paraquat. In Siufaga most farmers who mixed vegetables with taro hand weed. Weeds are spread around the growing taro plants as mulch. Weeds are then left to grow with the taro to protect the corm. Farmers believe that weeding before harvest results in the taro becoming inedible *(sūsū)*.

Although taro mulching was common among all farmers interviewed, vegetable mulching was not. Mulching attracts the Giant African Snail (GAS) and causes severe vegetable crop losses. GAS does not impact taro growth making the practice feasible.

3.3.2.2.1. Use of herbicide

In Siufaga 79.5 percent of the respondents and in Savaia 91.9 percent of the respondents used herbicide to clear their land before taro cultivation (Table 16). The commonly used glyphosate[25] is popular amongst farmers for land clearing. Farmers call it "seven days" because it takes approximately seven days before the weeds die down and farmers can plant their taro. Paraquat[26] is used for weeding in between the taro plants during the taro's growth. The sprayed weeds are left as mulch.

[25] Glyphosate is the active ingredient in the commonly known Roundup brand of herbicide.
[26] Paraquat is the active ingredient in the commonly known Gramoxone brand of herbicide.

Table 16: Use of herbicide

Villages	Herbicide use		Non-herbicide use (hand clearing)	
Siufaga, Savaii	79.5%	(35)	20.5%	(9)
Savaia, Upolu	91.9%	(34)	8.1%	(3)
All other villages	57.7%	(15)	42.3%	(11)

Note: Number in parenthesis denotes the value of n

3.3.2.3. Component 3: Rotations or sequences and associations of crops including trees which could include nitrogen-fixing legumes

3.3.2.3.1. Crop rotations or sequences

One form of crop rotation which is practiced by village farmers in Samoa is fallowing. Fallow periods for the villages are 7.51 months in Siufaga, 13.95 months in Savaia and 17.67 months in all other villages. Farmers in Samoa do not plant legumes during this fallow period but allow for the natural regrowth of the area.

3.3.2.3.2. Crop association including a legume

Farmers in Siufaga randomly plant vegetables such as cucumbers (*Cucumis sativus*) and watermelon (*Citrullus lanatus*) within their taro plantations to provide soil cover and an additional source of income and food for their family. Farmers in Savaia tended to grow their vegetables in separate plots from taro.

Farmers from both Siufaga and Savaia randomly planted dadap between the taro rows. This practice was also observed in the villages of Aopo, Sapapalii, Safaatoa, and Salani. According to the local farmers, dadap is considered the main source of nitrogen for taro. Before taro cultivation, some farmers cut down the dadap to provide mulch and nitrogen for the plant. Some farmers in Savaia opted not to use dadap because they believe it harbors pests and diseases of taro. However, other leguminous trees such as the *Gliricidia* were used in these cases. In some situations, dadap or *Gliricidia* was used as a hedgerow (Table 17).

Table 17: Use of CA

Villages	Zero-tillage	Mulching	Mixed cropping	Use of dadap	Use of mucuna	Fallow periods (months)
Siufaga, Savaii	100% (44)	100% (44)	100% (44)	97.7% (43)	0%	7.51
Savaia, Upolu	100% (37)	100% (37)	100% (37)	70.3% (26)	0%	13.95
All other villages	100% (26)	100% (26)	100% (26)	100% (26)	0%	17.67

Note: Number in parenthesis denotes the value of n

3.3.2.3.3. Diversity of crops and livestock

Table 18 shows that all farmers interviewed grew taro. Yam and giant taro were commonly grown and sweet potato was the least commonly grown plant. These crops were grown under papaya, cocoa, coffee or leguminous trees or in combination with each other. Cultivated tree crops such as cocoa, coconuts, and bananas were commonly found in the plantations along with papaya grown from seeds distributed by birds. Coffee was not commonly grown in Siufaga and Savaia. Frequently grown vegetables were eggplants, beans, pumpkin, cucumber, tomato, slippery cabbage, and pineapple. Lettuce and cabbage were the least popular vegetables grown by the households.

Farmers from all villages maintain diversified livestock including pigs, chickens, and cattle. Horses and sheep were uncommon. Sheep was recently introduced in the early 2000 and horses are used to transport produce from the farm sites to the village.

Table 18: Common root crops, tree crops and vegetable crops grown and livestock raised by the village farmers

Villages	Siufaga, Savaii		Savaia, Upolu		All other villages	
			Root crops			
Taro	100%	(44)	100%	(37)	100%	(26)
Yam	80%	(35)	84%	(31)	69%	(18)
Giant taro	59%	(26)	89%	(33)	23%	(16)
Cassava	14%	(6)	24%	(9)	0%	(0)
Sweet potato	9%	(4)	24%	(9)	0%	(0)
Xanthosoma spp.	11%	(5)	0%	(0)	0%	(0)
			Tree crops			
Cocoa	48%	(21)	62%	(23)	54%	(14)
Coconuts	41%	(18)	49%	(18)	46%	(12)
Coffee	2%	(1)	0%	(0)	0%	(0)
Bananas	73%	(32)	92%	(34)	85%	(22)
Papaya	75%	(33)	84%	(31)	88%	(23)
			Vegetable crops			
Pumpkin	16%	(7)	22%	(8)	23%	(6)
Pineapple	18%	(8)	19%	(7)	4%	(1)
Watermelon	16%	(7)	0%	(0)	0%	(0)
Tomatoes	20%	(9)	16%	(6)	0%	(0)
Slippery cabbage	20%	(9)	16%	(6)	8%	(2)
Cabbage	9%	(4)	3%	(1)	4%	(1)
Eggplants	34%	(15)	19%	(7)	12%	(3)
Beans	27%	(12)	11%	(4)	8%	(2)
Lettuces	2%	(1)	0%	(0)	0%	(0)
Cucumber	30%	(13)	43%	(16)	15%	(4)
			Livestock kept			
Cattle	14%	(16)	35%	(13)	15%	(4)
Chickens	70%	(31)	46%	(17)	35%	(9)
Pigs	7%	(3)	22%	(8)	38%	(10)
Horse	5%	(2)	3%	(1)	0%	(0)
Sheep	0%	(0)	0%	(0)	4%	(1)

Note: Number in parenthesis denotes the value of n

3.3.3. Limitations and benefits of the mucuna

Sixty-one percent of people from Siufaga said that the benefits of the mucuna were not obvious to them because their knowledge about the plant is limited. Twenty-seven percent of the respondents in Siufaga said that their lack of understanding of mucuna was because extension outreach efforts were ineffective i.e. did not include everyone, and too few training were

provided. Forty-five percent saw the limited land area as being an issue. Eleven percent noted the plants' fast growth would be an issue and require expensive herbicide to control. Seven percent of the households responded that the mucuna wraps itself around the taro plants and is labor intensive to control. Seven percent of the households responded that it did not make a good cover crop and that their soils were still exposed to the heat of the sun once the plant died. Seven percent said that it had no other purpose; it was not edible and livestock cannot graze it.

For Savaia, 70 percent of the respondents did not know or were not sure about the limitations of the mucuna. Eleven percent of the farmers noted that the mucuna programs were ineffective. For farmers who heard about the plant or observed its growth, eight percent said the plant grew too fast and it has the potential to become a weed. Sixteen percent of the farmers also said that because of its fast growth, it wraps itself around the taro plants requiring additional labor to remove it. Furthermore, it can eventually kill the taro if it is not controlled and would require herbicide to control its growth. Around five percent of the households said that the mucuna did not make a good cover crop and that it has no other purpose e.g. for food or for feeding livestock.

Seventy-seven percent of the households from all other villages were not sure of the problems. Thirty-three percent said that farmers are unaware because of ineffective outreach efforts. Eight percent said that it was a weed, requiring additional labor to control the plant and eventually needing herbicide to control its growth. Twelve percent said that it has no other purpose.

Respondents from Siufaga were not sure about the benefits of the mucuna (77 percent). Twenty-three percent said that it kills other weeds and it improves soil fertility. Eighty-one percent of Savaia respondents did not know what the benefits of the plant were, 11 percent said that it kills other weeds and eight percent said it improves soil fertility. Similarly, 92 percent of the respondents from all other villages said that they were unfamiliar with the mucuna benefits; eight percent said it improved soil fertility and it controlled weeds (Table 19).

Table 19: Limitations and benefits of the mucuna

Villages	Siufaga, Savaii		Savaia, Upolu		All other villages	
Problems with mucuna						
Not obvious	66%	(29)	70%	(26)	77%	(20)
Limited land	45%	(20)	0%	(0)	0%	(0)
It is a weed/needs herbicide	11%	(5)	11%	(4)	8%	(2)
Grows too fast	5%	(2)	8%	(3)	0%	(0)
Labor intensive	7%	(3)	16%	(6)	8%	(2)
Not a good cover crop	7%	(3)	5%	(2)	0%	(0)
Has no other purpose	4%	(2)	5%	(2)	12%	(3)
Mucuna programs are ineffective	27%	(12)	11%	(5)	33%	(9)
Benefits of mucuna						
Not obvious	77%	(34)	81%	(30)	92%	(24)
Kills other weeds	14%	(6)	11%	(4)	4%	(1)
Improves soil fertility	9%	(4)	8%	(3)	4%	(1)

Note: Number in parenthesis denotes the value of n

3.3.4. Communication channels used with respect to mucuna outreach efforts

Table 20 shows that most farmers were unaware or unfamiliar with the mucuna plant i.e. 39 percent from Siufaga, 22 percent from Savaia and 46 percent from all other villages. For those who did hear about the mucuna plant, 20 percent in Siufaga heard about the plant from lead farmers or opinion leaders within the village and 20 percent from other village farmers. Sixteen percent of the farmers heard about the plant through MAF and 11 percent from USP. For households in Savaia who heard about the plant, 43 percent heard about it from MAF, 35 percent heard about it from other lead farmers, five percent heard about it from other village farmers and three percent from USP. For all other villages, 23 percent heard about the plant from lead farmers, 15 percent from other village farmers and 15 percent heard about it from MAF.

3.3.4.1. University of the South Pacific's on-farm trials

The University of the South Pacific (USP) conducted four on-farm trials to compare the impacts of mucuna as a fallow crop to farmers current practices. The trials lasted for the duration of the taro's production cycle of nine months. Farmers' lands were used for the trials, but farmers were only passive on-lookers and as a result, very few farmers heard about the mucuna through this channel.

3.3.4.2. Ministry of Agriculture and Fisheries demonstration plots

The Ministry of Agriculture and Fisheries (MAF) conducted two training sessions within the respective villages that they implemented their demonstration plots. In all villages, MAF used lead farmers who were also chiefs. In the village of Savaia, the lead farmer and the high chief of the village involved all the farmers within their village during the training sessions. In the village of Siufaga and Sapapalii, the lead farmers involved their farmer's associations and close family members and friends. The rest of the villagers were excluded. Thus, MAF and the lead farmers in Savaia were more effective in raising awareness about the plant compared to the other villages.

Table 20: Where the farmers heard about the mucuna

Communication channel	Siufaga, Savaii		Savaia, Upolu		All other villages	
Not familiar with the plant	39%	(17)	22%	(8)	46%	(12)
Lead farmers	20%	(9)	35%	(13)	23%	(6)
Other village farmers	20%	(9)	5%	(2)	15%	(4)
MAF	16%	(7)	43%	(16)	15%	(4)
USP	11%	(5)	3%	(1)	1%	(1)

Note: Number in parenthesis denotes the value of n

3.4. Discussion

3.4.1. Comparing the relative advantage, compatibility, and complexity of current practices over mucuna as a cover crop

"We need to change farmer's mindset to adopt new methods" are comments often read in the context of new initiatives aimed at developing Samoa's agriculture at the village level (Toleafoa, 2014; SPC, 2016). These comments are often raised when village farmers in Samoa discontinue the use of introduced "improved" farming practices, for example, the case of mucuna as a cover crop. Literature suggests that the slow or non-adoption of introduced practices is often due to farmers not perceiving that the introduced practices has a relative advantage over current ones (Pannell, 2006; Greiner, 2009; Corbeels et al., 2014) or that the practices are too complex and are not compatible with current ones (Rogers, 2003). In the case of Samoa, the farmers provided

specific examples of the limitations of mucuna based on their observations during the training provided by MAF using demonstration plots and through the USP on-farm trials. Using the innovation attributes framework provided by Rogers (2003) the limitations of the mucuna compared current practices suggest that this is the primary reason that farmers did not adopt the use of this introduced CA practice as a cover crop.

3.4.1.1. Relative advantage

The relative advantage of an introduced practice is seen as the degree in which it is better than the one it intends to replace (Rogers, 2003). Some studies have shown that introduced practices do not necessarily improve farmers' current situations (Pannell, et al., 2006; Giller et al., 2009). This is seen in the case of village farmers in Samoa. Increased labor input and increased costs associated with herbicide use were two comparative disadvantages farmers foresaw with the use of mucuna over current practices.

According to a farmer from Savaia, intercropping of mucuna with taro requires the farmer to make time to unwrap the mucuna from the taro plant. Taro maintenance normally takes two hours per day and introducing mucuna would mean that a week would be required to perform the same job (M.M., personal communication, March 19, 2017). Farmers also had the option of using mucuna as a fallow crop and slash it to form thick mulch. Farmers observed that the problem with this method is that farmers would need to know where the main stem of the plant was. "Markers would have to be placed at the plants growing point, but again this is time-consuming for the farmers especially if they have large land areas" (A.T., personal communication March 16, 2017). Labor issues with the use of CA practices have also been reported in other parts of the world such as in Africa (Rola et al., 2009), and rural communities of India (Lai et al., 2012) and Nepal (Halbrendt, 2014) and specifically labor issues with mucuna in controlling its vigorous growth (Fischler & Wortmann, 1999; Buckles & Triomphe, 1999; Manyong & Houndekon, 2000).

During the early 1980s at the peak of Samoa's taro exports, labor was not seen to be an issue because able family members would work on the plantations together (O'Meara, 1990).

However, over time urbanization and out-migration has resulted in fewer family members working the land. This study found that an average of two family members cultivates and maintain their family's taro plantations and carry all other agriculture activities such growing of other crops, harvesting, and transportation of the produce to the village site. Due to the labor shortage, farmers have adopted the use of herbicide for weed control i.e. 79.5 percent of Siufaga farmers, 91.9 percent of Savaia farmers and 57.7 percent of all other farmers reporting that herbicide was used due to labor scarcity in their households. "There are limited people in my family and the herbicide is my family's *aumaga* (working youth in the family)" (L.P., personal communication, 17 January 2017).

"Mucuna is important, but from my observations, if the plant reaches our native forests, it can kill off important trees. Farmers do not have the time to control the growth of the plant, and we do not make regular visits to our native forests. I think it is best to leave it in areas where farmers are fallowing and regularly visiting" (L.T. personal communication, February 17, 2017). Farmers highlighted that due to the plant's vigorous growth; it would require herbicide to control it. According to Goh et al, (2007), the mucuna plant is fast-thriving in nature and regenerates rapidly, and if uncontrolled, it can smother plants such as the oil palm (*Elaeis guineensis*). Other studies also support the claims made by the farmers with respect to the plant's vigorous growth (Fischler & Wortmann, 1999). Due to its vigorous growth, farmers observed that they would need to procure herbicide to control it. This study found that 45 percent of Siufaga farmers and 16 percent of Savaia farmers lacked finances to procure herbicide. Therefore, in encouraging farmers to adopt mucuna, herbicide costs are seen to be an important consideration for village farmers in Samoa; and in particular for farmers in Siufaga who are seen as the more rural of the two villages with fewer opportunities to sell their products to generate an income to buy herbicide.

Siufaga and Savaia farmers believed that the mucuna would not provide sufficient ground cover i.e. cover the whole area with no soil exposed to the sun. According to the farmers, once the mucuna dies down, the mulch is not seen to be thick enough to cover the whole soil area that they intend to cultivate with taro. Furthermore, farmers from both villages observed that aside

from its introduction as a cover crop, the mucuna provided no other benefits e.g. it is not edible to both humans and animals and it has no other economic value. Essentially, no relative benefits exist for using the mucuna over their current practices (Rogers, 2003).

3.4.1.2. Complexity

The degree to which an introduced practice is seen as complex and difficult to understand and implement by the farmer can be a barrier for its adoption (Rogers, 2003; Cullen et al., 2008). In the case of mucuna, farmers from Siufaga were concerned about the use of the mucuna in their small land area. With Siufaga farmers practicing mixed cropping, their concern was that the mucuna will overtake the growth of their vegetables and taro and kill them off. A key informant in the village of Savaia showed a plot of land where he had tried to plant sweet potato in the area where mucuna was previously planted. The mucuna overtook his sweet potato crops because it was growing close by.

Farmers from Savaia and Siufaga further observed that it takes the mucuna eight months before it produces mature seeds. Literature suggests that the *Mucuna pruriens* found in tropical countries are annual plants. The farmers would need to wait a year for the plant's life cycle to complete (Lampariello, et al., 2012). In Siufaga farmers normal fallow period is six or seven months and according to the farmers, this makes it uneconomical for them to wait for the plant to reach a stage where they can save seeds and form a mulch when they could be using the land area to grow more taro or other crops. In Savaia, even though farmers fallowed their land for just over thirteen months, they also brought up this concern.

The introduction of mucuna would mean that farmers need to change their farming approach. According to T.S., (personal communication, March 16, 2017), a general lack of understanding exists among the farmers on the optimum plant spacing and the time of planting between mucuna and taro and other vegetable crops if used in a mixed cropping system. According to Tarawali et al., (1999) competition exists for plant nutrients between maize mixed cropped with mucuna when planted on the same day.

Another complexity which could arise from the use of mucuna is whether it will harbor GAS in its mulch form, which means that farmers must use slug bait to control GAS. Considering the potential herbicide costs already observed by farmers, additional GAS costs may further limit its adoption by farmers.

3.4.1.3. Compatibility

An introduced innovation is deemed compatible when it is consistent with existing values of the intended adopters (Rogers, 2003). This study shows that the CA practice of mucuna as a cover crop was perceived as incompatible with village farmer's current practices and beliefs with their soil. For example, farmers at the village level use the dadap (*Erythrina variegata*) tree legume to help improve soil fertility; they do not use cover crops. Dadap has been used for generations by Samoan village farmers and scientific evidence indicates that dadap provides shade for farmers while they work and improves soil fertility (Iosefa, 1997). Although farmers noted that certain vine-like plants i.e. mile-a-minute (*Persicaria perfoliate*) are allowed to naturally grow in their fallowed land areas to make weeding easier (Paulson, 1994) planting of vines during fallow periods is not practiced.

Samoan village farmers are unique because observations show that their current farming practices are classified as CA i.e. zero-tillage, mulching and mixed cropping with dadap. These practices have enabled Samoan village farmers to maintain their soil health for generations (Paulson & Rogers, 1997). Recent soil analysis conducted by USP in forty sites belonging to farmers exporting taro concluded that the soils were generally healthy in terms of its chemical, biochemical and biological composition (Guinto et al., 2015). They observed that the general good health of the soils could be due to the absence of mechanical tillage at the village level (Guinto et al., 2015). Another factor which has aided Samoan soils could also be due to the Taro Leaf Blight (TLB) epidemic which resulted in the loss of Samoa's major export crop. Farmers were forced to leave the land that was usually cultivated with taro to fallow for more than 20 years as researchers worked to breed TLB resistant taro varieties. During this period, no other major export crop was grown and farmers planted other subsistence crops such as giant taro (Agriculture Sector Plan, 2011-2015). The TLB was a 'blessing in disguise' because it allowed

farmers to leave their land fallow so that soil nutrients could be replenished (T.I., personal communication, October 26, 2016). Thus, village farmers may not yet see the need to change their practices. In Taveuni, Fiji, where taro cultivation has been intensive (i.e. no soil cover, tilling) for more than 22 years, farmers yields have declined due to soil nutrient depletion which has significantly reduced taro corm quality making it unacceptable for export (Sharma, 2016). Reports by SPC, (2014) shows a more favorable response and uptake of the CA practice of mucuna as a cover crop by these Fijian farmers.

Nevertheless, Samoan farmers are not free from soil health issues. Studies show that Phosphorus and Potassium are limited and soil pH would need to be increased to a range of 5.5-6.5[27] in most of the taro plantations (Guinto et al., 2015.; SPC, 2011). As farmers increase taro production to cater to the export markets, the use of the introduced CA practice of mucuna as a cover crop may become inevitable for them and future research will need to work with individual farmers to identify what the limiting factors are in terms of their soil health and to assist them to make the necessary changes to address these issues. In Siufaga for example, 34 percent of the farmers indicated that they had issues with soil acidity and that the taro corms were very small. Farmers in Siufaga refer to their soils as *"logola le palapala"* which means that their soils are too dry, and are exposed to the sun. Farmers in Siufaga would be expected to have more soil health problems compared to the other study site of Savaia and all other villages, this is because their land areas are smaller by comparison and they are forced to utilize the same piece of land area shortening their fallow periods to seven months. However, despite smaller corm yields, some farmers in Siufaga said that "we still get enough food for our family" (U.V., January 5, 2017). Their plantations are mainly for food and at times a source of income.. In this farmers are more concerned with meeting the daily family food needs from their plantation rather than selling taro, so smaller corm yields may not be an issue. However, future programs need to be aimed at individual farmers depending on their objective. For example, some farmers may wish to start expanding taro production and enter the export market which may require more assistance with their taro management practices.

[27] This is the optimum range for dryland taro production (SPC, 2011).

Savaia farmers, as well as farmers from all other villages, are able to expand production into new land because they have larger land areas i.e. one household has on average greater than 39 acres. Therefore, they may not see the need to use a new system of farming because their current systems work. They can expand taro production into new areas and leave previously cultivated land to fallow. Perhaps with time and as soil fertility starts to show more noticeable signs of decline, farmers may see the need to utilize new farming management systems which could be in the form of the introduced CA mucuna as a cover crop.

3.4.2. Ineffective outreach strategies

The introduction of a new idea is always surrounded by uncertainty as to whether it will improve the current situation of the intended adopters (Rogers, 2003). To reduce uncertainty, farmers have to be able to trial the practice and to observe the limitations and the benefits of the system over time (Pannell et al, 2006; Greiner, 2009). In the case of mucuna in Samoa, respondents were uncertain about the plant i.e. 39 percent from Siufaga, 22 percent from Savaia and 46 percent from all other villages. In addition, 66 percent from Siufaga, 70 percent from Savaia and 77 percent from all other villages were not sure about the benefits of the system. Seventy-seven percent 81 percent and 92 percent of farmers from Siufaga, Savaia, and all other villages respectively said that that the limitations were not obvious or they were not sure about the plant's limitations. One farmer said U.U gave me some mucuna seeds, I put it in the plate cabinet but my grandchildren found it and played with it. I don't know where the seeds are now…..I don't understand about this plant" (A.F., personal communication, January 6, 2017). Another farmer said that he took the seeds and threw it into the land next to his house because he did not know what to do with the plant (A.A., personal communication, January 7, 2017).

The farmers in Savaia were more aware of the mucuna, this was mainly because the lead farmer involved the village council in creating awareness about the plant. The village council is effective in this case because this is the traditional decision-making unit within the village which is well respected by village members (O'Meara, 1990; Paulson, 1994). Furthermore, MAF has a research station and an extension officer residing in the village which has facilitated more

communication between the farmers and the government about the plant. However, even the lead farmers and the village council in Savaia failed to adopt the mucuna.

Farmer's unfamiliarity with the plant may be due to the lack of sufficient time to trial the plant and to make observations for themselves. Although some farmers were able to observe the plant through the demonstration plots and the on-farm trials, the duration of the studies of only nine months and with only two training sessions were insufficient to allow farmers to make a decision about the usefulness of the plant to their situation. Farmers have to try the practice for themselves to help in their decision-making process (Greiner, 2009).

Rogers (2003) concluded that adopters within a society include innovators, early adopters, early majority, late majority and late adopters. Therefore, the target of communication strategies within a given society should not follow a standard "blueprint" but rather different strategies should be used to target the different groups within a society (Bohlen et al., 1961). Although MAF was effective in utilizing lead farmers or opinion leaders in creating awareness about the mucuna, the study showed that the lead farmers themselves failed to use the mucuna which could also explain why other village farmers did not adopt mucuna.

Although one farmer from Salani said that he heard about the mucuna on a television program, all farmers within the study sites do not recall a television program of this nature. Therefore, MAF needs to rethink their communication strategies in relation to the introduction of future CA programs such as the mucuna. At present, the study shows that MAFs mass media efforts to raise awareness are ineffective, and they are only working with one set of farmers and disregarding other groups and individuals within the villages as seen through their links only with lead farmers.

3.5. Conclusion

This study shows that farmers in Samoa are using CA practices of zero-tillage, mulching and mixed cropping of taro with vegetables and a legume tree known as dadap. These practices have been ongoing for many generations which have helped farmers maintain their soil health. Because heavy tillage has been absent, this has helped maintain farmer's soils from rapid depletion of Soil Organic Matter. Furthermore, farmers during the TLB era have left their land fallow for more than 20 years with no major export crop during this period. This gave farmers' soils enough time to replenish lost nutrients. These factors have helped farmers maintain current taro yields and they do not see the need to use the introduced practice of mucuna as a cover crop. Particularly when the introduced CA practice of mucuna as a cover crop, holds no relative advantage, is complex and is not compatible with farmers' current practices and beliefs. Furthermore, farmers were not given the opportunity to try the mucuna and observe the limitations and benefit of the plant themselves. Even though they used lead farmers to generate awareness about the plant, the lead farmers themselves were not convinced about the plant's contribution. This study concludes that at present, village farmers are not willing to change their system from one that currently works to one that contains too many uncertainties.

The study recommends that MAF and other donor agencies involved in the program need to rethink their communication strategies so that they target all members in the village and not just the lead farmers. They also have to implement these training programs for longer periods of time to give farmers the chance to observe and to trial the practice for themselves. MAF and donor agencies involved in mucuna and future CA programs need to work with individual farmers to understand their soil health needs. Soil analysis should be undertaken to identify those farmers who are most at risk of soil health issues within the respective villages and assistance should be given based on farmers' needs. In relation to farmers from Savaia and all other villages with larger land areas, perhaps with time, farmers may utilize the practice of cover cropping as issues with soil health becomes inevitable in the future. MAF and donor agencies should plan to continue working with farmers in implementing cover cropping programs and

trials and make comparisons to current practices of mixed cropping and dadap use to reduce uncertainty over time.

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Chapter 4

Perceived economic and socio-cultural factors determining farmers decisions to not adopt introduced Conservation Agriculture (CA) practices at the village level - the case of mucuna (*Mucuna pruriens*)

Abstract

This paper discusses the perceived socio-cultural and economic factors influencing farmers decisions to not adopt an introduced Conservation Agriculture (CA) practices at the village level in Samoa. The study focused on the CA practice of mucuna (*Mucuna pruriens*) as a cover crop in taro (*Colocasia esculenta*) plantations. The study utilized 107 in-depth interviews with farmers, participant observations and discussions with eight key informants to establish some of these reasons. The study found that village farmers were each had a major contribution in their village to ensure social cohesion with their society. For example, farmers are high chiefs, talking chiefs, wives of chiefs or the youths of the youths in the village. As part of their roles, farmers fulfill obligations to their families, church, and the village itself. Fulfilling these obligations in the form of monetary contributions is funded mainly through their farming activities. Because farming plays an important role in their livelihood, farmers have adapted their methods to cater to their farming problems such as herbicide use to cater to the labor shortage. Also, farmers, current farming systems are adapted to cater to natural disasters such as cyclones. With systems that have been catered to suit their needs, and to fulfill their cultural obligations, it is difficult for farmers to change to new systems with uncertain benefits as seen in the case of mucuna.

4.1. Introduction

Conservation Agriculture (CA) is favored globally as a sustainable approach to address poor soil health (Lienhard et al., 2013; Gliessman, 2014) and increase yield and profits over time (Hobbs et al., 2007; Mishra et al., 2015; Lanckriet et al., 2012). CA includes three types of best practices: minimum mechanical disturbances, permanent organic soil cover, and diversification of crop species grown in sequences and/or associations (FAO, 2015). One CA practice introduced to village farmers in Samoa is the use of cover cropping in the form of mucuna (*Mucuna pruriens).* Agricultural research institutions in Samoa are concerned that with taro cultivation increasing to meet the local and export demand, soil health issues will arise as per the pre-Taro Leaf Blight (TLB) era (Ofori, n.d.). Literature has indicated that declining soil health is considered to be the biggest threat to sustainable agriculture in the PICs (Anand, 2016).

Despite the best intentions of introducing CA practices, farmers do not readily adopt them (Knowler & Bradshaw, 2007; Pannell et al., 2006; Giller et al., 2009; Greiner et al., 2009; Greiner, 2015). This was seen in the case of cover cropping using mucuna, where the introduction of the practice in 2012 at the village level by the Australian Center for International Agricultural Research (ACIAR), government of Samoa, University of the South Pacific (USP) and the Secretariat of the Pacific Community (SPC) resulted in no-adoption of the practice by the village farmers. Although no common variables explain why some farmers adopt and others do not (Knowler & Bradshaw, 2007), the perceived risk associated with adopting a CA practices in the face of uncertainty surrounding its use has been identified as an overarching factor in its non-adoption (Greiner et al., 2009; Anderson et al., 2015).

Risk is defined as the probability associated with the uncertainty that impacts an individual's welfare, and in this case, its impact on the livelihood of the farmer (Hardwood et al., 1999). Subsistence and semi-subsistence farmers from the Pacific Island Countries (PICs) are exposed to a range of risks that impact their livelihoods including, natural disasters such as cyclones, strict export regimes, fluctuating market prices for export crops, high cost of inputs, lack of credit, lack of markets to name a few (Malua, n.d.). Farmers have established management

strategies to ensure that these risks do not prevent them from having enough food and income to support their families (Paulson & Rogers, 1997).

Essentially, new practices introduced have to help farmers address their problems and improve on their current systems. However, if farmers do not observe any relative advantage of the new system over current practices, if the system is not compatible with current beliefs and system and if the system is too complex, farmers are unwilling to change from their current systems (Rogers, 2003; Pannell, 2006). Farmers have to observe the benefits and limitations of an innovation to reduce their uncertainty during the decision-making process to ensure that an innovation is adopted Rogers (2003) otherwise farmers will resort to old methods (Cochran, 2005).

With statistics showing that more than three-quarters of Samoa's population is dependent on agriculture (Agriculture Census, 2015), a change to a system with too many uncertainties is too risky especially since village farmers have social, cultural and economic contributions to fulfill in their community (O'Meara, 1990; Paulson & Rogers, 1997). The objective of this chapter is to highlight the potential socio-economic and cultural factors influencing farmers' decisions to discontinue the use of mucuna.

4.2. Methodology

4.2.1. Village selection

This study focused on the soil health program, which introduced mucuna as a cover crop into six villages on the island of Upolu and Savaii from 2010 to 2015 with on-farm trials being conducted by a USP Research Assistant in the villages of Safaatoa, Salani, Aopo, and Siufaga. The Ministry of Agriculture and Fisheries (MAF) extension service became involved in the program to create awareness about the use of the mucuna to combat, soil health issues and to reduce herbicide use.

In the villages of Siufaga and Savaia, customary land belonging to farmers who were considered leaders in their community in agriculture and as chiefs (i.e. lead farmers) was used by MAF for their demonstration plots. These lead farmers were part of farmer associations that consisted of their relatives and friends. The high chief in the village of Savaia involved the village council thereby encouraging all village farmers in the community to join in the training sessions. While the specific content of the training is not clear, discussions with the communities involved indicated that the training focused on the cultivation of the mucuna seeds and the taro tops. The second training demonstrated the maintenance of the mucuna in a fallow system where slashing of the mucuna and planting of the taro in mucuna mulch was demonstrated. Finally, the taro was harvested and yield data were collected.

4.2.1.1. Description of Siufaga, Savaii and Savaia, Upolu

Siufaga is located on the eastern coast of the big island of Savaii, Samoa, approximately 10 km from the wharf located in the island's capital, Salelologa. Savaia is located on the south-west coast on the island of Upolu.

Religion is important to the daily lives of the villagers and it is common to see the community volunteering their time to church activities. Attending church services particularly on Sundays is a norm in the villages. Siufaga has the Seventh Day Adventist (SDA), the Congregational Christian Church of Samoa (CCCS), and Assembly of God (known as the Voice of Christ) church located in the village. In the village of Savaia, the Congregational Christian Church of Samoa is located within the village and the Pentecost church is located along the road going towards the plantations (S.T., personal communication, September 7, 2017).

In both villages, farmers use customary land belonging to their family for crop cultivation. Although some farmers also used land belonging to the village and in the case of Siufaga, land belonging to the church, this study was interested only in land belonging to their families. This ensured that only one variable was considered as not all families had the advantage of using church or village land. Taro is the most common staple crop grown for home consumption and for sale. Bananas (*Musa spp.)*, giant taro (*Alocasia macrorrhizos*), *Xanthosoma spp*., and

breadfruit (*Artocarpus altilis*) are also grown, mainly for subsistence purposes. In Siufaga, mixed cropping of taro with other vegetables is a common farming practice. In Savaia, mixed cropping also happens though vegetables are grown in separate plots from taro. Farmers in Savaia have fairly large land areas, around 39 acres, per household, compared to Siufaga, they have smaller land areas of five acres, per household by comparison.

4.2.1.2. Socio-demographics of the study sites

Table 21 shows the socio-demographics for the study sites. Most of the respondents completed their education at the secondary level with few (5 percent) reaching the tertiary. Most of the respondents interviewed in Siufaga were males with 48 percent interviewed being females. Most of the respondents in Siufaga were in their late 40s and on average one household has six members.

In Savaia, most of the respondents completed their education at the secondary level (78 percent) and the primary level (17 percent) with few of the respondents reaching the tertiary level (5 percent). Thirty-seven households or 64 percent of the household from Savaia were interviewed with seventy percent of the respondents being male and 30 percent being female. Similar to Siufaga, the respondents were in their late 40s and one household has an average of seven people.

Socio-demographic data from all other villages were similar to that of Siufaga. Most of the respondents reached the secondary level (42 percent) or the primary level (58 percent). Only one female was interviewed and the majority of whom were males. The age of the respondents was comparable to those from Savaia and Siufaga i.e. the respondents were in their late 40s. Similarly, the average number per household of 6.08 was comparable to Siufaga and Savaia.

The respondents had all been farming for more than 20 years in Siufaga and all other villages and more than 15 years in Savaia. The standard deviations indicate variation in the data collected particularly for the age and duration of farming variables; however, the average number of people per household was very consistent.

Table 21: Socio-demographics of study sites

	Siufaga	n	Savaia	n	All other villages	n	Data for Samoa[28]
Educational level							
Primary	31%	14	17%	6	42%	11	60%
Secondary	52%	23	70%	26	58%	25	51%
Tertiary	48%	21	30%	11	0%	1	49%
Sex of respondents							
Male	52.5%	42	56.3%	45	96%	25	51%
Female	47.5%	38	43.8%	35	4%	1	49%
Age of respondents							
Mean age male	46.13	23 *(SD = 13.10)*	49.58	26 *(SD = 13.90)*	46.36	25 *(SD = 11.99)*	24.2
Mean age female	49.19	21 *(SD = 11.59)*	49.73	11 *(SD = 16.87)*	60.00	1 *(SD = N/A)*	23.7
Mean age per respondent	47.59	44 *(SD = 12.36)*	49.62	37 *(SD = 14.60)*	46.88	26 *(SD = 12.05)*	23.9
Mean number per household	6.25	44 *(SD = 2.71)*	7.14	37 *(SD = 2.58)*	6.08	26 *(SD = 2.50)*	7.00
Farming duration (years)	22.02	44 *(SD = 14.80)*	18.49	37 *(SD = 12.62)*	26.04	26 *(SD = 13.12)*	N/A

SD: Standard deviation
N/A: Data not available

[28] Source of data: Samoa Bureau of Statistics, 2017

4.2.2. Data collection

4.2.2.1. In-depth interviews

In-depth interviews required the researcher to listen to the respondent (in this case the village farmer) as they expressed their ideas and feelings (Bernard, 2002). A list of questions (Table 22) provided guidance during the discussions; however, other aspects of the farmer's issues were noted.

In total, 107 in-depth interviews were conducted with the village farmers over a period of seven months (December 2016 to July 2017). Forty-four interviews took place in Siufaga and 37 in Savaia. Spot checks, to ensure that responses from these villages were consistent with those from other study sites, were carried out using 26 in-depth interviews with village farmers in all other villages (Sapapalii, Aopo, Safaatoa, and Salani) where mucuna was also introduced. The *pulenuu* and the high chief in the area recommended the farmers selected.

Prior to conducting research in Samoa, approval was sought from the Institutional Review Board (IRB) of the University of Hawaii. Within the selected villages, support was sought from the respective village high chief (*Sa'o o le nuu*) and *pulenuu*. An introductory letter was provided as a written record that the researchers' respective university approved the study. Seeking the approval of the prominent village members ensured that other village members participated in the study. The chief and *pulenuu* informed other community members of the purpose of the study. The villagers were receptive to participating and were helpful in directing the researcher to other farmers within the village.

Table 22: Guide questions during the discussions

	Question guidelines
1	What are some of the challenges you face with your plantation work?
2	What are your main sources of income?
3	How much do you receive from each source per week?
4	What are your priorities in the village, in your family and your church?
5	What are your thoughts on the mucuna as a cover crop?

At the beginning of the discussion with the respondent, the purpose of the study was explained to the farmers and their verbal approval was sought before beginning the interview. Notes were taken and a recorder was used to record the discussion. The household heads were sought out for interviews, however, during some the interviews, other family members also took part in the discussions, which was counted as one interview. The involvement of the family members during the conversation clarified some of the issues and provided an improved understanding of the allocation of resources and relationships between family members.

4.2.2.2. Key informants

Eight key informant interviews were utilized during the study. Key informants included consultants, lead farmers, extension officers, and scientists involved with the Soil Health Program introducing mucuna as a cover crop. Discussions with key informants guided question development and provided the context for the introduction the mucuna as a cover crop. Clarity on the introduction of mucuna and the people involved in these programs was also sought from the key informants. Furthermore, key informants, especially the village opinion leaders' (high chiefs, talking chiefs, and *pulenuu*) views on certain cultural protocols were utilized.

4.2.2.3. Participant observation

Bernard (2002) describes three main types of participant information useful for research: complete participant, participant observer, and complete observer. Five benefits of participant observation, include (1) it opens up the discussion and makes it possible to collect all kinds of data; (2) reduces the problem of reactivity (people changing their behavior because they are aware they are being observed); (3) helps the researcher to formulate and ask sensible questions; (4) gives a better understanding of what is going on through the experience of being in the community; (5) allows the researcher to participate and learn more about the problem by becoming part of the social structure e.g. the case of O'Meara (1990) when he was bestowed an orator chief title and thereby gaining access to important information through the village council in his study village in Samoa.

The complete participant occurs if the researcher is involved as a member of the community without the community knowing that they are a researcher. This involves deception and creates risk because community members may mistrust the researcher should they later find out. A participant observer can either be an insider (from the community) or an outsider who are interested in recording all aspects of life around them in the study community. A complete observer is a researcher that follows people around to record their behavior.

Emerson (1995) gives similar descriptions of participant observation but he uses the terms immersing and "getting into place". Immersing into village activities allows the researcher to gain an intense sense of daily routines and concerns in the study site. "Getting into place" permits a more detailed and closer-to-the-moment look at the way of life (Emerson 1995).

This study used what Bernard (2002) describes as a participant observer and what Emerson (1995) defines as "getting into place". Using this method gave a holistic understanding of the issues faced by the farmers daily, particularly in relation to their cultural, family and village obligations. It also gave a sense of the issues they meet in their daily agricultural work and specifically with the use of the mucuna. In some situations, the research used immersion through participation in marketing activities with both the men and the women in the village, and in cultural obligations (e.g. a funeral within the host family).

4.2.2.4. Focus group discussions

Five focus group discussions took place: two in Siufaga, two in Savaia and one in Sapapalii. The focus group discussions in Siufaga were more formal with the women and males being separated and informed in advance about the sessions. The focus group discussions in Savaia and Sapapalii occurred more informally with the male farmers who were resting in the village market building after their morning plantation work and women who were waiting for their children to return from school. These discussions provided insight into farmer's uncertainty about the mucuna and the risks that they face with their current plantation work.

4.2.3. Data analysis

The interviews were conducted in the Samoan language and transcribed and translated into English by the researcher. On average one interview took 43 minutes with descriptive and thematic analysis being utilized in this study. Thematic analysis involves familiarization with the data by immersion, sorting out and categorizing sections of texts as well as sayings into common themes. While sorting out, evolving patterns were grouped into relevant and/or common themes and then coded. Descriptive statistical analyses were conducted using the Statistical Package for Social Scientists (SPSS v 23).

4.3. Results

4.3.1. Problems with farming

Forty-five percent of Siufaga farmers listed low taro prices and a lack of markets as their main concern as did forty-one percent of Savaia farmers and 42 percent of farmers from all other villages. Insufficient labor was also high on the farmer's list of problems with 45 percent, 16 percent and 23 percent of farmers from Siufaga, Savaia, and all other villages respectively, noting this.

Limited financial resources to procure herbicide were noted by Siufaga farmers at 45 percent and Savaia farmers at 16 percent respectively. It was less of an issue with all other villages. Similarly, the limited land area was also a problem for Siufaga farmers (45 percent) compared to Savaia and all other village farmers. Thirty-four percent of Siufaga farmers also indicated that the poor state of their soils was an issue and that financing any inorganic or organic fertilizers was a major constraint due to the costs involved. Theft was another problem brought up by Siufaga farmers (11 percent).

Thirty-five percent of Savaia farmers indicated that taro worms were a major problem. Rotting caused by a taro virus, which was recently reported by MAF affected taro in both Upolu and

Savaii. Farmers also noted the ineffectiveness of agriculture programs with 14 percent respondents in Savaia, 27 percent in Siufaga and 35 percent from all other villages mentioning this issue.

Farmers also mentioned pest problems with the Giant African Snails (GAS) affecting vegetable growth with around 34 percent of respondents from Siufaga, five percent from Savaia and 15 percent from all other villages noting this problem. The lack of water and rockiness of land for vegetable production were other problems brought up by Siufaga farmers. The high cost and lack of good quality vegetable seeds were also raised by seven percent of Siufaga farmers, three percent of Savaia farmers and four percent of farmers from all other villages (Table 23).

Table 23: Problems with farming

Problems	Siufaga, Savaii		Savaia, Upolu		All other villages	
Low prices of taro/Lack of markets	63%	(28)	57%	(21)	61%	(16)
Lack of labor	45%	(20)	16%	(6)	23%	(6)
Lack of finances for herbicide	45%	(20)	16%	(6)	4%	(1)
Limited land area	45%	(20)	0%	(0)	0%	(0)
Programs brought in do not help	27%	(12)	14%	(5)	35%	(9)
Soil issues/Acidic soils	34%	(15)	8%	(3)	19%	(5)
GAS for vegetables	34%	(15)	5%	(2)	15%	(4)
Hardy weeds	18%	(8)	14%	(5)	4%	(3)
Worms eating corm of taro	2%	(1)	35%	(13)	0%	(0)
Not enough soil cover	14%	(6)	0%	(0)	8%	(2)
Lack of water for vegetables	5%	(2)	0%	(0)	19%	(5)
Theft	11%	(5)	3%	(1)	4%	(1)
Lack of vegetable seeds/expensive	7%	(3)	3%	(1)	4%	(1)
Rockiness of land	7%	(3)	0%	(0)	0%	(0)

Note: Number in parenthesis denotes the value of n

4.3.1.1. Labor availability

The average amount of available labor per household for Siufaga, Savaia, and all other villages was two individuals. Family labor ranged from one to five for each respective household per village (Table 24). Most farmers spent an average of four hours on their agricultural activities per day. Estimating labor was difficult because farmers had other responsibilities to fulfill in their village.

Table 24: Mean number of family members working the farm per household

Village	Family labor	Minimum family labor	Maximum family labor
Siufaga, Savaii	1.73	1	5
Savaia, Upolu	2.00	1	4
All other villages	1.81	1	3

4.3.1.2. Increased herbicide use resulting from insufficient labor

This study only collected data from villages that used herbicide. The results showed that 79.5 percent of Siufaga farmers, 91.9 percent of Savaia farmers and 57.7 percent from farmers from all other villagers used herbicide as a substitute for labor. Herbicide usage in Savaia and Siufaga is higher compared to the data from the Agriculture Census (2017) (Figure 7).

The data collected from the study sites particularly Savaia showed higher herbicide use by farming households compared to the census data. Savaia has larger plantations of taro (i.e. 12 acres under taro cultivation) therefore requiring herbicide for weed control. Surprisingly, the number of households using herbicide in Siufaga was quite high despite their having less than an acre under taro cultivation. This could be due to the hardy nature of weeds reported by farmers in this area compared to Savaia making it necessary for them to use herbicide for weed control. However, all other villages were slightly lower than the 2015 data because farmers in Aopo did not use herbicide.

4.3.1.3. Distance to farm

Farmers in Savaia traveled further to their farms (42.57 minutes) compared to farmers from all other villages (36.54 minutes) and Siufaga (24.55 minutes) (Figure 8).

4.3.1.4. Marketing of taro and frequency of sales

Figure 9 show that 82 percent farming households in Siufaga and 70 percent in Savaia sold their taro in the village market. Fifty-four percent of the farmers responding from Savaia sold their taro in the main town market, and 34 percent to taro exporters. Very few of the farming households filled direct orders. For respondents from all the other villages, 62 percent exported

taro and 42 percent filled direct orders, while 27 percent sold by the roadside and nine percent sold in village markets.

Farming households from Savaia were more consistent in selling their taro (62 percent) compared to those from Siufaga (27 percent) and all other villages (15 percent). For those who sold on an irregular basis, sales were dependent on the occurrence of a family, church, or village obligation. If these obligations did not occur, they would not sell their taro. Eighteen percent of respondents from Siufaga, 11 percent from Savaia and eight percent from all other villages consumed all of the taro at home (Figure 10).

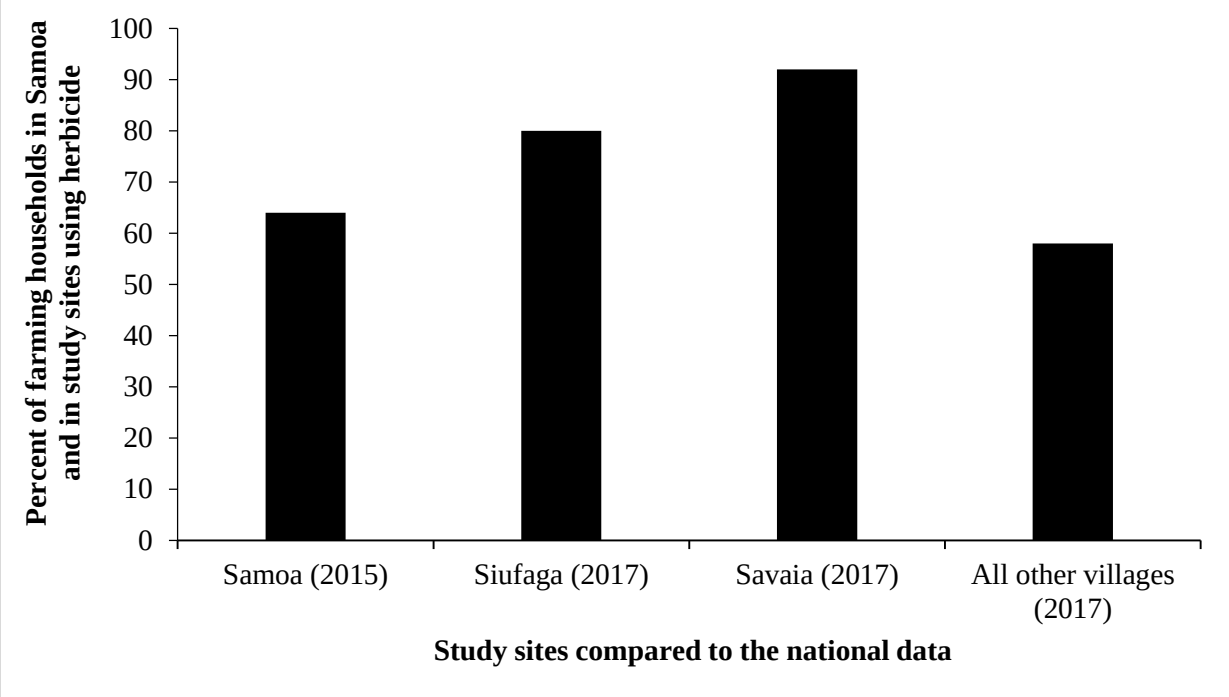

Figure 7: Percent of farming households in Samoa and study sites using herbicide. Data for the year 2015 was extracted from the Agriculture Census (2015). Data for the study sites was estimated from in-depth interviews

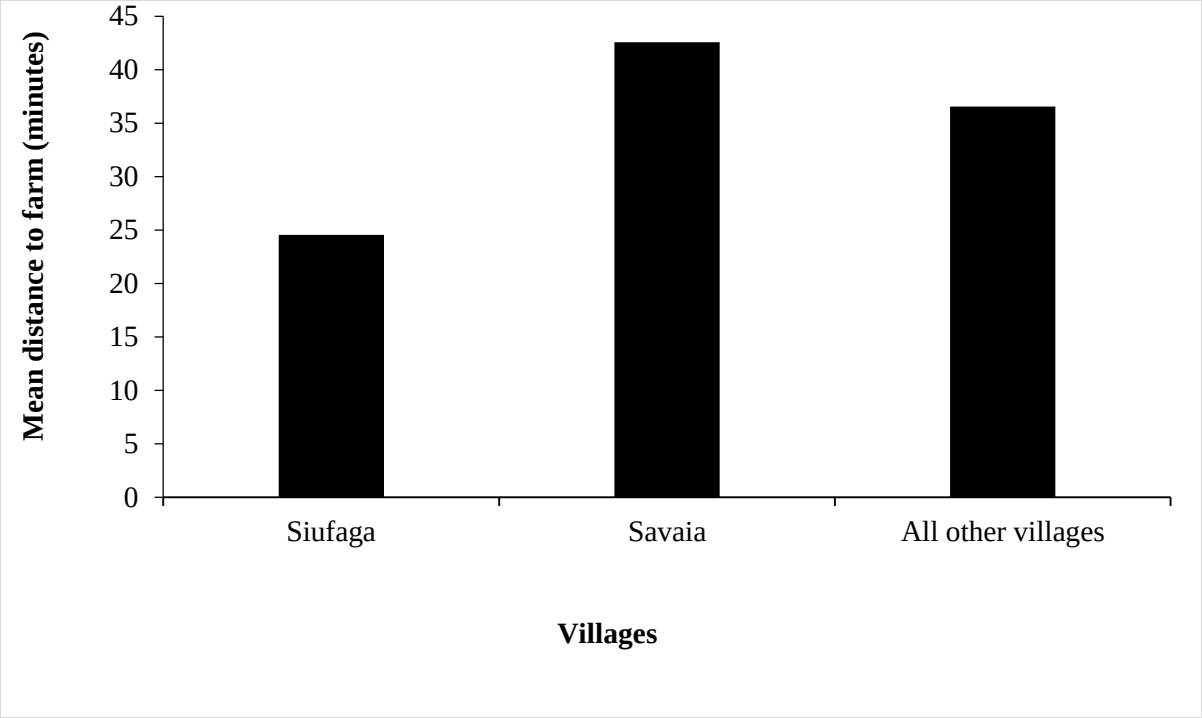

Figure 8: Mean distance to farm in minutes per household per respective village

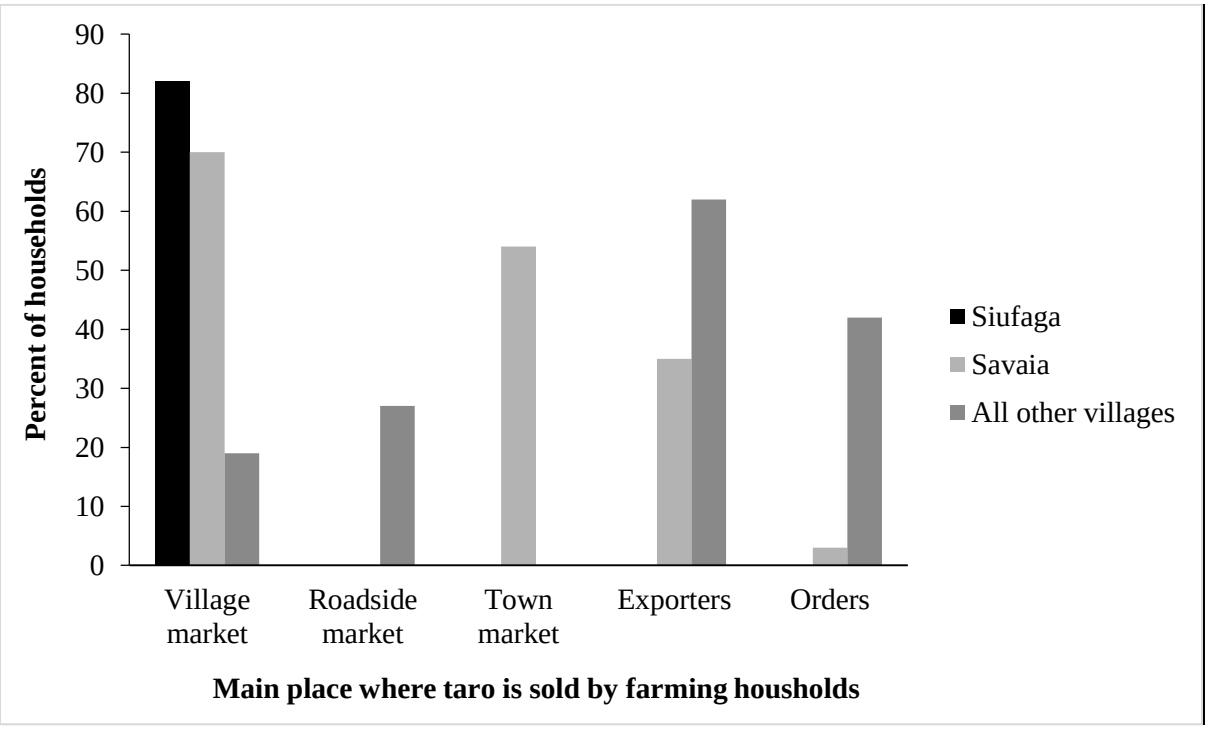

Figure 9: Main place of selling taro for household per respective village

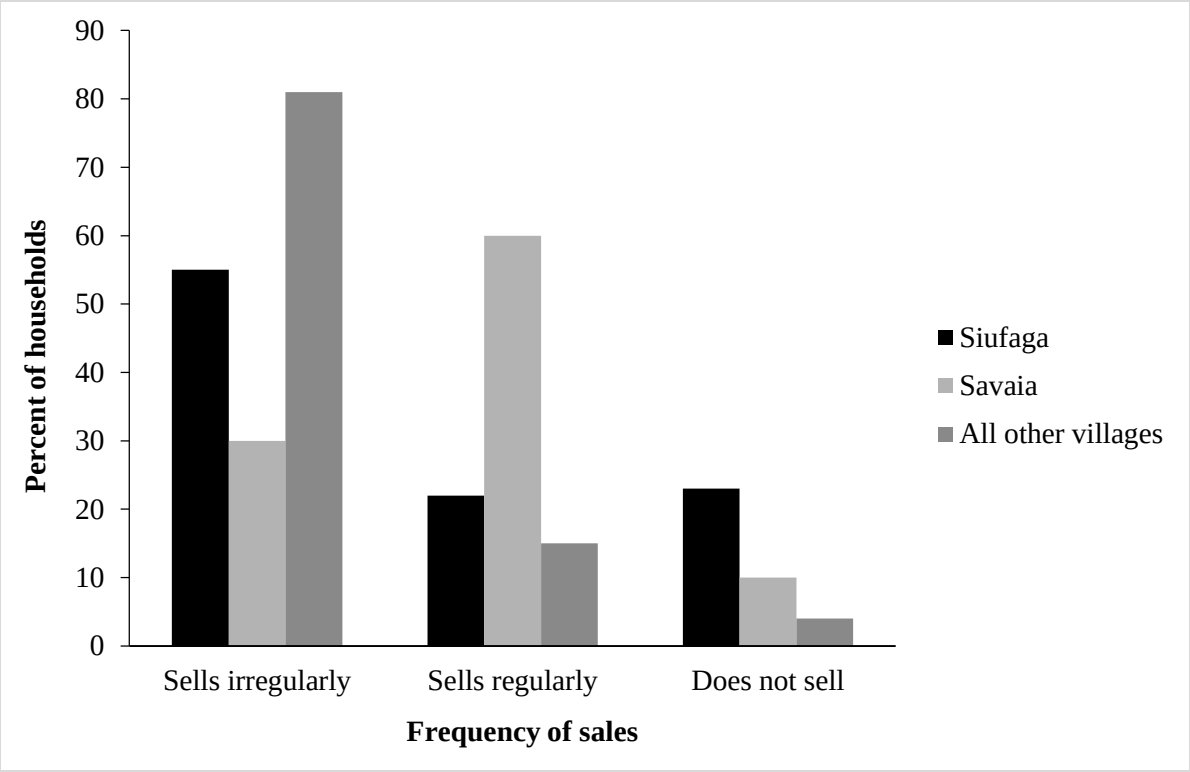

Figure 10: Frequency of sales for households per respective village

4.3.2. Comparing income from farming and other sources

Figure 11 shows that 77.3 percent of the farming households responding from Siufaga earned more of their income from farming compared to other sources such as remittances (54.5 percent), salaried work (56.8 percent) and fishing (31.8 percent). For farmers in Savaia, they also earned most of their income from farming (89.2 percent) compared to, remittances (56.8 percent), salaried work (56.8 percent) and fishing (5 percent). For All other villages, 88.5 percent of their income was from farming, 23.1 percent was from remittances and 34.6 percent was from salaried work. The amount is more than 100 percent because farmer's income was earned from more than one source. The results also showed that out of the 51 people who received remittances, 11 percent received this money regularly from children or family overseas to supplement their income from farming. The rest of the participants (i.e. 89 percent) received remittances from family only when support was needed to fulfill a family obligation.

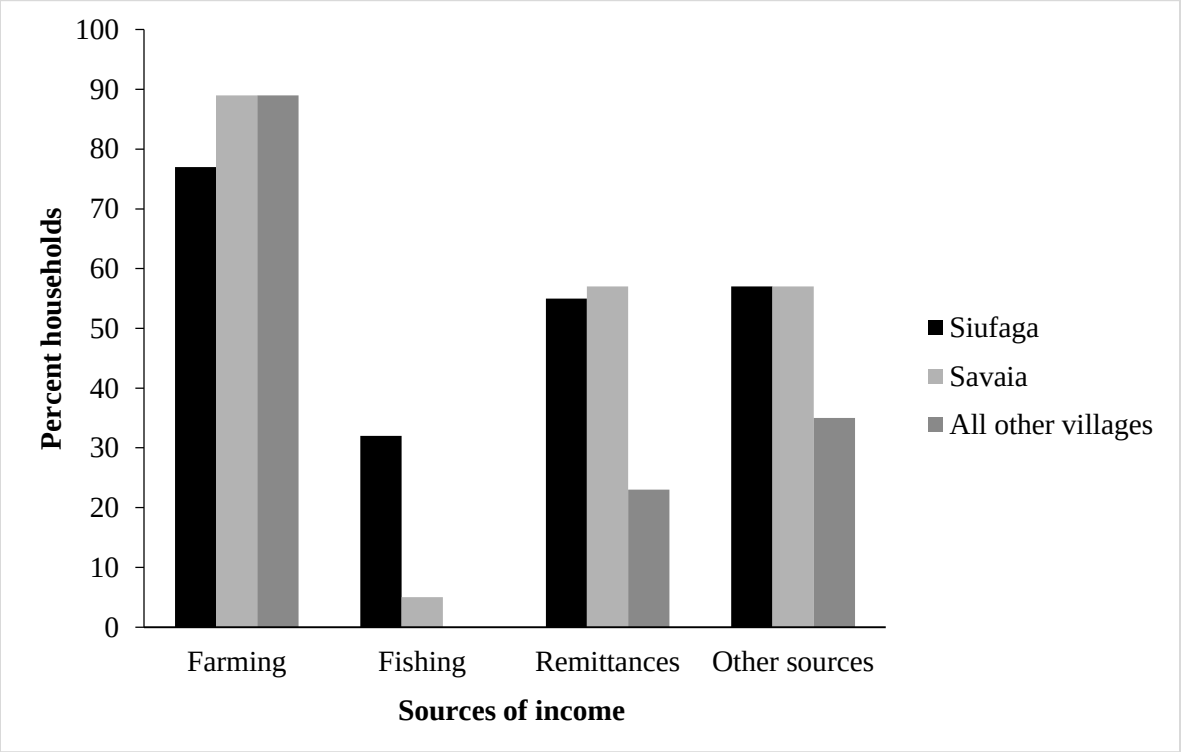

Figure 11: Source of income for households per respective village

Table 25 shows the average income for the respective villages per year. In Siufaga this was USD 9,013 per year, for Savaia it was higher at USD 20,592 per household per year and USD 13,185 for all other villages. The mean farm income per household was lowest for those from Siufaga with a mean of USD 3,322 per year. It was higher in Savaia at USD 10,088 per year and USD 5,021 in all other villages. Farmers from Siufaga earned USD 5,691 from other sources compared to farming. For Savaia the average income other than from farming was USD 10,504 and it was USD 8,164 for all other villages.

These results show that Savaia earns more from farming compared to the other villages. Savaia also earns slightly more from other sources such as remittances or salaried work. This difference could be due to the fact that Savaia has more support systems in place such as remittances and the majority of the households have people that are employed compared to the other villages. The respondents from this village were also slightly more educated compared to Siufaga and all other villages and their location on Upolu island puts them at an advantage for job opportunities

compared to Siufaga and other villages. Furthermore, observations showed that leaders in this community were actively involved in pursuing export market opportunities for the villages. One taro exporter within the village buys from the Savaia farmers and exports taro to New Zealand on a monthly basis.

Table 25: Income per household

Villages	Mean income per household per year (USD)	Mean farm income per household per year (USD)	Mean income per household per year from other sources (USD)
Siufaga, Savaii	9,013.00	3,322.00	5,691.00
Savaia, Upolu	20,592.00	10,088.00	10,504.00
All other villages	13,185.00	5,021.00	8,164.00

4.3.3. Farmers expenditure

Farming households were asked how much they spent on the church, village, and family obligations. Siufaga farmers spent an average of USD 1,243.08 per year on family obligations. For Savaia, this was higher at USD 11,164.32 per year. For All other villages, USD 4,780.92 was spent per year on family obligations.

Households from Siufaga spent an average of USD 1,803 yearly on church obligations. Savaia farmers spent USD 3,800 per year and all other villages spent USD 1,023 per annum. For village obligations, Siufaga households spent an average of USD 574, Savaia spent USD 464 and all other villages spent around USD 496 annually (Table 26).

Table 26: Mean amount spent on family, church, and village obligations

Villages	Family obligations[29] per year (USD)	Church obligations per year (USD)	Village obligations per year (USD)
Siufaga, Savaii	2,325.00	1,803.00	574.00
Savaia, Upolu	11,164.00	3,800.00	464.00
All other villages	4,781.00	1,023.00	496.00

[29] Family obligations include family funerals, title bestowments and weddings. Funerals varied during the year, sometimes there would be one or five. For the analysis, we estimated an average of four per year per household Title bestowments would not happen twice in one year for one family because of the expenses involved.

4.4. Discussion

4.4.1. Problems with farming at the village level

This study shows that farmers at the village level face considerable risks as subsistence, semi-subsistence farmers (Harwood, et al., 1999). Their top three issues raised by farmers include the lack of markets for their taro and fluctuating taro prices, lack of labor and insufficient capital to purchase herbicide[30]. For example, M.O., from the village of Aopo is the main link between the village farmers from his village to one of the main exporters. He said that when taro was first exported, exporters would procure a 22kg bag of taro for USD 37.20. Prices decreased to USD 28 and they are now being purchased for between USD 21.2 – USD 17.5. Recently he was asked by the exporter to organize from his whole village 100 (22kg) bags of taro. He was still contemplating how to fairly divide the quantity demanded between all the village farmers, considering that there are 56 farming households in their village (M.O., personal communication, February 18, 2017).

Fluctuating taro prices is a result of a growing number of farmers cultivating taro for the export market. One farmer in Sapapalii who owns more than 100 acres says he alone can supply one exporter. He plants 4,000 to 5,000 *tiapula* (taro tops) per day. These farmers with more land area and who could afford to hire labor took up the bulk of the orders leaving little opportunity for other farmers.

Another major issue that farmers brought up was the lack of labor. With an average of two family members working the plantation farmers have resorted to using herbicide to cater to insufficient labor. The agriculture census from 1989 to 2015 shows an increase in the use of herbicide among farming households. Recent statistical data shows that 64 percent of farming households use herbicide (Agriculture Census, 2015). This shows that farmers at the village level can adapt their methods to cater to their current problems. The case of village farmers in

[30] Out of all the six villages interviewed, Aopo was the only village that did not use herbicide or any other form of chemicals in their plantations. Their forefathers established rules to ban the use of any chemical in their village and this rule is still observed by farmers today.

Samoa incentivizing and adapting their methods and customs has also been reported by O'Meara, (1990).

Farmers have increased the use of herbicide despite some believing that herbicide destroys the soil structure. "I know it is herbicide because our farmers use too much of it to control weeds and this has destroyed our soil and caused our taro corm to become so small. In the past, my grandparents could harvest taro with large corms, and they never used herbicide. But now we use too much" (N.T., personal comment, January 26, 2017). Similar beliefs were expressed by the village farmers in Aopo which is why their village council established laws banning the use of any chemical in their village. Their belief is that any chemical including herbicide destroys soil structure and soil fertility.

Despite a common belief amongst villagers that herbicide destroys soil structure and soil fertility, they continue to use herbicide to control weeds because of labor issues. Farmers found it difficult to afford the costs of herbicide because of insufficient capital. In these situations, farmers would resort to weeding by hand out of necessity or borrow the herbicide chemical and a knapsack sprayer from their neighbors when they could. "It takes some time to save the money, but when I can, I usually buy one liter of roundup…. Sometimes when I need herbicide and I have no money, I would ask my neighbor for a couple of caps full of the chemical. I cannot afford a knapsack sprayer; the cheapest is USD 80 so I borrow one from my neighbors" (L.P., personal communication, January 17, 2017).

4.4.2. Farmers have built their methods to cater to natural disasters and food insecurity

Increasing herbicide use to cater to labor shortages is just one adaption method used by farmers. Village farmers have developed systems that work for them. Several areas will be discussed here such as the role of the village structure, and the role that subsistence and semi-subsistence farming plays in ensuring that food and income security is met for the village farmers.

4.4.2.1. The important role played by the village council

The village council plays a key role in village decision making (O'Meara, 1990; King & Faasili, 1999). Studies have shown that the village council in Samoa has been instrumental in ensuring that the villagers have enough food, especially after natural disasters. For example, Paulson, (1994) observed that after Samoa was hit by cyclone Ofa and Cyclone Val in the early 1990s, chiefs instructed households to plant a set number of taro tops so that within six to seven months, their families would have food. Failure to meet the set quota of *tiapula* planted resulted in a hefty fine.

During this study, similar observations were made. For example, in all the villages where the mucuna was introduced, the village council has established rules that every farming household in the village meets the quota of planting anywhere between 500 to 1,000 *tiapula* per month. This is to ensure that there is a continuous supply of food for their families. In the study site of Siufaga, this quota is 500 taro tops per month per household and likewise in the village of Savaia.

Another example of successful initiatives by the village council in Savaia is the *Talomua* (translated as the first harvest) program. The village council started the program to encourage the youths and the communities to grow food for their families so that theft within the village could be reduced. The *Talomua* program has been ongoing in the village for more than 20 years in the village and has been very successful and adopted by the government and other villages (T.R., personal communication, May 27, 2017).

4.4.2.2. The role of subsistence and semi-subsistence farming

The very nature of subsistence and semi-subsistence farming has sustained PIC communities for generations and it still does to this day (Paulson & Rogers, 1997; FAO, 2009). With all the risks that farmers face nowadays, establishing systems that work for them is important. For instance, all village farmers practice mixed cropping, U.U., (personal communication January 19, 2017) said that he diversifies his crops not only to provide diversity in food for his family and in cases where he cannot sell his taro, he can sell is other crops such as papaya, pineapple and processed

cocoa. Diversifying crops not only helps to diversify income and nutrition, but it also helps local farmers to buffer against natural disasters. Taro and giant taro are crops which can quickly recover after a cyclone. Paulson (1994) in her studies in Samoa also reported that diversification of crops at the village level was a management strategy used farmers to buffer against cyclones, droughts as well as pests and diseases.

4.4.3. Low income from farming

Farmers at the village level received low returns from farming compared to other sources such as remittances and salaries. Low economic returns from farming were also reported by O'Meara, (1986) during his studies in Samoa. Despite the low income, the results of this study show that farmers are heavily reliant on their plantations to support their families rather than on other sources of income of remittances and salaried work.

In fact, this study found that even though 54.5 percent of farmers from Siufaga 56.8 percent of farmers from Savaia and 23.1 percent of farmers from all other villages received remittances, the funds were not used to supplement their income to meet their daily needs, but rather to fulfill a family obligation. Only nine percent of respondents received remittances on a regular basis from their children to support their daily needs. This means that 91 percent of all those who received remittances used the money to meet village, family or church obligations e.g. funerals, weddings or title bestowments. Village farmers are very much aware that families overseas are struggling to make ends meet. A couple in their mid-fifties in the village of Siufaga told me that one of their sons is currently in New Zealand and that he is also struggling to support himself. They only ask for money when they cannot fulfill their cultural obligations.

This study also shows that 45.5 percent of respondents in Siufaga and 43.2 percent in Savaia did not receive remittances. These findings are consistent with the studies done by Le De (2015) which concluded that not all members in a village, and particularly the vulnerable members of the community, receive remittances. Therefore, these families sole source of income is through

farming. From this income, farmers have to fulfill not only their families' daily needs but their cultural obligations.

4.4.4. Farmers commitment to the church, village, and family

4.4.4.1. Farmers commitment to plantation work, marketing and the importance of social obligations

Village farmers play more than one role within their community. This is seen in the farmer's responses to their responsibilities within the villages. Although they classified themselves as farmers, they also held other positions within the village. These positions require certain obligations such as commitment to the church, family, and church which can all be categorized as cultural obligations. One of the most difficult variable to investigate were the hours farmers spent working on their plantations and the amount of time allocated to their cultural obligations.

Time allocation depended on the immediate circumstances of the farmer, e.g., the need for taro or food for that day, the need to generate an income to meet an obligation, the need to plant a new taro patch or the necessity of maintaining an existing one. For example, for this study, I had arranged the focus group discussion with the Siufaga high chief a month in advance. Upon the day of the activity, an unexpected visit from the health department in selected villages in Savaii occurred. The farmers had to allocate some of their time to the focus group discussion in the morning and the rest of the day was spent in the meeting with the government officials. During this day, no farming activities occurred because everyone was busy with the welcome ceremony, food preparation, and other formalities.

Their commitment to their culture is also seen in how they market their produce. Most farmers from Savaia, Siufaga, and all other villages would sell irregularly. Most farmers only sold their produce to meet a family, church, or village obligation. One of the talking chiefs' wives said that they mainly keep for home consumption; however, a *fa'alavelave* (family obligation) would cause them to sell their taro, fish, and any other produce they had to ensure that their *tusaga* (contribution) was met. Essentially, farmers in Samoa are not committed to their plantation work and other farming activities fulltime. They work on their farms when the need arises

because they have other obligations that they need to fulfill for their families, church, and village. In fact, Schoeffel argues in one of her papers "where are the farmers" that Pacific growers are not "farmers" as the word is internationally understood i.e. commercially oriented, but they have adapted methods to produce a larger surplus for sale (Schoeffel, personal communication, November 27, 2017). This is seen in the case of farmers from Savaia, where although they have larger land areas, they only produce enough to meet their obligations and the market demand for taro. Further discussion with the farmers indicated that very little money goes back into their plantation or is, saved (O.N., personal communication February 17, 2017).

4.4.4.2. Farmers commitment to the church

Another example to show that farmers' commitment to their cultural obligations is through their donations to their church and how they look after their pastors. Pastors are well respected and they are important members of a Samoan village. The acceptance of a new pastor into a village is a big occasion, and all village members are involved despite differences in church denominations. The main reason for this is to show respect to the new pastor and to accept them as one of the villagers. This occasion involves the exchange of food and money between the two groups. For example, U.U one of my key informants from the village of Siufaga has an adopted son who is a pastor of the SDA church. His son informed him that he was being moved (*si'itia*) to another SDA congregation. In preparation for this event, U.U who is the high chief of his family called a meeting amongst all his close relatives. Each family chief was to contribute USD160 and four cartons of tin fish (equivalent to USD 80). The family collected more than USD 800 and 28 cartons of tin fish. These were gifted to the chiefs and pastors of the host village.

Farmers are also active in terms of fundraising for church activities. Some of the interviews for this study had to be shortened because of these obligations. For example, during my time in the village of Siufaga, I went in search of the LMS assistant pastor for an interview. Our interview had to be kept short because he was heading to town with the pastor to procure building supplies to repair the church hall. Most of the village farmers whom I had earlier interviewed in the week were gathered in the church hall cleaning and painting it. This work lasted for about a week and

it was necessary for the *fa'amati* preparations. The *fa'amati* is a time when all the congregation members of the CCCS and the LMS church prepare gifts of mats and other household items which are presented to their pastor and his wife in the month of March. This is not unique to Siufaga and is practiced in most other Samoan villages and mainly by these two church denominations. During this week, farmers left their plantations and concentrated on preparations for the *fa'amati*.

4.4.4.3. Farmers commitment to the village

According to the farmers, monetary contributions to village activities do not happen frequently and it does not cost as much compared to church and family commitments. For example, L.K. (personal communication, July 15, 2017) who is a talking chief in the village of Savaia, said that when there is a village activity and food is needed, then farmers will contribute local chicken, taro, and fish. Sometimes monetary contributions are made, but the amount is small. However, farmers will commit their time to any village related activities to ensure the success of the activity.

4.4.4.4. Farmers commitment to family obligations

Village farmers contribute substantial monetary amounts to family obligations. In the village of Siufaga, farmers contributed the least compared to the farmers from Savaia and all other villages. On average, about three obligations occur per year which the farmer contributes towards. This, of course, varies per year depending on the number of deaths in a family.

If a family obligation needs to be fulfilled, the family meets to determine the amount of money, and other non-monetary donations will be contributed. In one case, a family collected USD 44,000 for title bestowments. According to F.K (personal communication, April 17, 2017), his extended family members approached him for chiefly titles. Since seven family members requested this, he asked each person to contribute USD 6,286 each. The pastor who led the prayer during the ceremony was given USD 2,000. All other pastors in the village were gifted USD 800. The lead orator was presented with USD 800. All other chiefs in the village were gifted USD 120. Families only raise funds when titles are to be bestowed.

Expenses for funerals are slightly different from title bestowments. The amount given to a funeral depends on how close the person is to the deceased and the status of the deceased. The level of contribution increases as the closeness of the relationship status levels becomes. According to T.L. (personal communication, February 6, 2017), she and her husband contributed to five funerals in the year 2016 with the last one occurring just before Christmas. She estimated that they spent more than USD 800 for all the funerals in that year. Other farmers have recorded spending up to USD 2,000 on funeral obligations.

4.5. Conclusion

The objective of this study was to understand the socio-cultural and economic risks that would arise should farmers change their current farming practices to the introduced mucuna. The study found that farmers are already challenged with their current farming practices in terms of resources such as capital, and labor. However, despite these challenges, they have adapted their management strategies to suit their current limitations. Essentially, these systems have served them well during natural disasters, providing their main source of income and food. In fact, their plantation is their main source of income to meet their family, village and church obligations. Farmers receiving some form of support through remittances used it to support a cultural obligation.

Farmers committed to serving their community may be unable to take the risk of changing their current way of farming to one that has not shown any potential as seen in the case of mucuna. A change could mean the loss of important income needed to provide for their family for food, income or even in times of natural disasters. The risk is made greater by the fact that not everyone has that support through remittances.

Future work on the mucuna needs to take into consideration the fact that it may be difficult to change farmers' mindset into using mucuna because they may never move away from their semi-subsistence nature as noted by Schoeffel. In fact, perhaps the best way is to give farmers enough

time to work with the mucuna and to make their own decision of whether the plant can be adapted to suit their current farming strategies.

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Chapter 5

Quantifying the reasons for the non-adoption of introduced Conservation Agriculture (CA) practice of mucuna (*Mucuna pruriens*) as a cover crop in the villages of Siufaga and Savaia, Samoa using the Analytic Hierarchy Process (AHP)

Abstract

With farmers at the village level in Samoa failing to adopt an introduced Conservation Agriculture (CA) practice of mucuna (*Mucuna pruriens*) as a cover crop, this study was initiated to see if differences in perceptions of those introducing the programs. The study focused on differences in perceptions of extension officers to that of the farmers as a possible hindrance to farmer's non-adoption of the CA practice. To identify whether perception differences existed, this study used the Analytic Hierarchy Process (AHP) multicriteria decision-making tool. The study found that differences do exist between the extension officers to that of the farmers. In particular were differences in their perceptions of the impact of mucuna for weed control. Farmers saw the mucuna as a weed which would require more herbicide which impacted their decision to reject the use of the plant. On the other hand, extension officers saw this as the least likely reason for the failed adoption of the practice. This study shows that extension officers are anticipating farmers' perceptions and they are not utilizing appropriate communication channels to show farmers the pros and cons of the mucuna over current practices. Extension officers need to take more time to extend the practices into the communities to help farmers reduce their uncertainty about the use of the mucuna.

5.1. Introduction

The diffusion of CA technology across farming societies is of interest worldwide particularly in areas where the main livelihood is agriculture and per acre productivity is declining, while farmers adoption of CA practices is slow or non-existent (Umar et al., 2011; Pannell et al., 2014; Ward, et al., 2016). The adoption of CA practices does not appear to be a "one model fits all" concept. Rather farmer's decision to adopt or reject an innovation is site and context specific (Rogers, 2003; Knowler & Bradshaw, 2007).

Sixty-eight percent of Samoa's population is dependent on subsistence and semi-subsistence agriculture for their livelihood. Taro (*Colocasia esculenta*) is the main staple and the primary cash crop in the country with an estimated 12,938 acres under taro cultivation and 17,733 major farming households growing taro (Agriculture Census, 2015). Taro holds cultural, monetary, and dietary significance in Samoa and its production was severely reduced with the arrival of the Taro Leaf Blight (TLB) caused by the fungus (*Phytophthora colocasiae*) in 1993. Even before the arrival of the TLB, scientists at the University of the South Pacific (USP) noted a decline in the taro yields in Samoa due to intensified taro cultivation by incorporating herbicide and shortened fallow periods (Ofori, n.d.). After 20 years of breeding TLB resistant varieties, production has rebounded and taro has again become a significant income generator for village farmers.

Since the export of TLB resistant taro varieties to New Zealand in 2010 (Radio New Zealand, 2010), farming households growing taro has increased by 17 percent based on data from the Samoa Agriculture Survey in 2015. Local, regional, and international institutions working in the agriculture sector are concerned that current taro expansions will result in soil health issues which were detected before the TLB (ACIAR project proposal, 2009; Agriculture Sector Plan 2010-2015; T.T., personal communication, October 16, 2016).

The concern on future soil health impacts led the Australian Center for International Agricultural Research (ACIAR), with the Secretariat of the Pacific Commission (SPC), the USP and the Samoa's Ministry of Agriculture (MAF) to initiate the introduction of mucuna (*Mucuna*

pruriens) as a cover crop through the Soil Health program. The broad goal of the program was to "develop strategies for improving soil health in selected Pacific cropping systems" (ACIAR Project Proposal, 2009: page 13). Discussions with farmers and extension officers indicated that the program ran from 2010 to 2015, and it aimed to provide continuous organic mulch, improve soil fertility, and reduce herbicide use through the use of the mucuna.

Mucuna was introduced into six villages in Samoa through separate on-farm trials conducted by USP and demonstration plots implemented by MAF extension officers. Three villages from the island of Savaii were involved – Sapapalii, Siufaga, and Aopo as well as three villages from Upolu – Safaatoa, Savaia, and Salesatele. Despite their involvement in the demonstration plots, and to some extent the on-farm trials, mucuna use was discontinued by the farmers within the respective villages upon completion of the program.

A barrier to the adoption of introduced innovations is differences in perceptions of those introducing the program to the intended adopters. Generally, these differences are influenced by socio-economic status, technical expertise and educational levels (Rogers, 2003; Jakku & Thorburn, 2009). However, in the context of development where aid is intended on improving livelihood through improved farming methods, extension officers perceptions can be influenced by funding availability, time restrictions and achieving institutional objectives (Tuilaepa, 2006). This differs from the village farmers perception of achieving food and income for today based off generation old farming practices that have stood the test of time (Thrupp, 1989; Tikai & Kama, n.d.). These differences described by Rogers (2003) as "heterophily" can be a barrier to the successful use of effective communication strategies in the diffusion of an innovation into a community.

The objective of this study is to investigate the differences between the village farmers and extension officers' perceptions regarding the introduced CA practice of mucuna. The differences in perceptions of the principle actors will inform future outreach efforts designed to promote CA practices. Understanding where the gaps are between the farmers and the extension officers will hopefully improve the way in which outreach efforts are designed and become more farmer-

focused. This study utilizes the Analytic Hierarchy Process (AHP) a multicriteria decision-making tool that quantifies the differences in the perceptions of the village farmers compared to extension officers.

5.1.1. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP) are multicriteria decision-making methods developed in the 1980s by Thomas Saaty (Figure 12). They are used to derive relative priority scales of absolute numbers from individual or group judgments (Saaty, 2004). The ANP is structured as a decision network while AHP is structured as a decision hierarchy. Both methods use a pairwise comparison to give weight components of the structure and each can address qualitative and quantitative multi-criteria problems (Pažek & Rozman, 2005). People transform feeling into a judgment that is expressed numerically within an elaborate and carefully thought out structure. Therefore, the combination of subjectivity and objectivity which allows for the trade-offs made by the individuals to be identified and compared across individuals. Decisions structured as a hierarchy reduces complexity and trade-offs between criteria and alternatives can be investigated (Mu and Pereyra-Rojas, 2017).

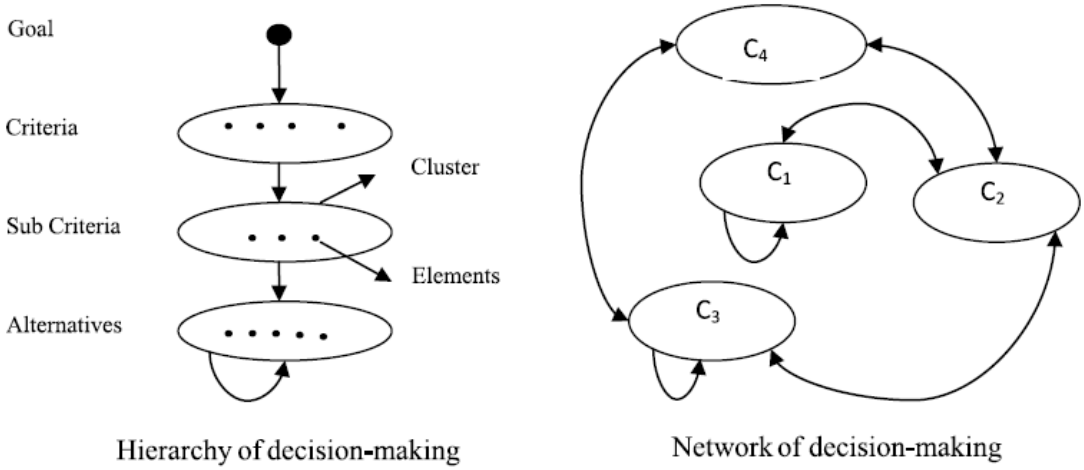

Figure 12: The AHP and ANP multicriteria decision-making methods developed by Thomas Saaty (Source: Azis, 2003 In: Sadeghi et al., 2012)

AHP has been applied to problems associated with resource allocation, forecasting, and healthcare. AHP is a proven method capable of producing results that come to an agreement with perceptions and expectations (Bhushan & Rai, 2004). In this study, AHP was used because of its simplicity because the problem could be arranged in a hierarchy allowing the focus to be on one level at a time. This makes AHP a powerful tool to use in order to understand the goals and trade-offs associated with adopting the CA practice of mucuna across the farmers and extension officers. The use of key informants, participant observation, focus group discussion and in-depth interviews aided in gaining a thorough understanding of the situation and an all-inclusive systematic approach to determining gaps between the extension officers and individual village farmers.

The first step in the construction of AHP[31] is determining the goal, criteria and various feasible alternatives. This is an important step in the model because it shows the relationship between the higher levels in the hierarchy to the ones below it. Secondly, data is collected from respondents in line with the levels in the established AHP model. Respondents make trade-offs at the different levels in the hierarchy using scales i.e. equal, marginally strong, strong, very strong or extremely strong. Pairwise comparisons are then made using an organized square matrix i.e. a pairwise matrix of the criteria and pairwise matrix for the alternatives. The normalized principal eigenvector gives the relative importance of the criteria and the alternatives being compared. A consistency ratio is calculated by taking the ratio of the consistency index and the random matrix. Allowance is made for error in human judgment, therefore, AHP allows for a consistency ratio of less than 0.1. This value implies that the respondents were generally consistent in their subjective judgments made.

[31] The AHP steps have been adapted from Bhushan & Rai (2004).

5.2. Methodology

5.2.1. Study sites

Data for this study were collected in two villages in Samoa; Siufaga in Savaii and Savaia in Upolu (Refer Figure 5 Chapter 3). These villages took part in the on-farm trials by USP and training using demonstration plots by MAF. The sites were selected based on the people's willingness to be interviewed and to work with the researcher to understand the non-adoption of mucuna as a cover crop[32] by the village farmers.

5.2.2. Data collection

5.2.2.1. Establishing the goals, criteria, and alternatives

The overall goal of this study was to understand why farmers were not adopting the introduced CA practice of mucuna. In-depth interviews were used to identify the primary factors that resulted in the non-adoption of the CA practice by the farmers. Focus group discussions were used to confirm the established criteria and alternatives. The three broad criteria include Extension, Economics, and Tradition. These are shown in Figure 13 for clarity.

5.2.2.1.1. Extension

This was defined as a community-based education and awareness program about the introduction of the mucuna that informed farmers about the benefits of the practice and how to use the practices on their farms.

Farmers in both villages said that the benefits of the mucuna plant were not obvious to them. These reasons stem from the fact that farmers were not given enough time to see the potential benefits of the mucuna. In the USP trials, farmers were passive onlookers, they were not given the opportunity to observe the benefits of the mucuna. In the MAF demonstration plots that lasted for nine months, farmers were active participants though only two training sessions

[32] Information on these study sites can be found in chapter 3.

occurred which limited the time that farmers could observe any benefits of the plant. Also, farmers were not given the opportunity to make comparisons between the mucuna to their current practices. Farmers identified that insufficient training and awareness about the mucuna were contributing factors to the lack of adoption of the plant.

Lack of community involvement according to the farmers is due to the fact that most members of their community were not involved. In Siufaga, only those farmers who were part of the lead farmer's association and family were included in the demonstrations. Other farmers were excluded. In the village of Savaia, most farmers were included, though some said that they were not included and women were generally excluded from the training.

5.2.2.1.2. Economics

Economics was defined as an insufficient supply of capital, land, and/or labor. Farmers from both villages said that additional labor would be required to control the mucuna because of its vigorous growth. Some farmers estimated that current practices require two hours per day to maintain their taro plantations. With the mucuna, the job that was previously done in two hours would now take one week because the plant has to be untangled from the taro plants. Furthermore, seeds have to be collected, and markers would need to be placed at the location where the seeds were planted to ensure that the main stems are removed to reduce it from becoming invasive.

Farmers also said that mucuna could become invasive if it was not controlled. Control would require the use of herbicide. Farmers said that they lack the capital to procure herbicide (i.e. glyphosate or paraquat).

Farmers in Siufaga have, on average, 5.66 acres of land and 0.97 acres is utilized for their taro plantations. Due to the limited land area, they make efficient use of the space by mix cropping taro with vegetables and the legume dadap. Farmers were concerned that because of the mucuna's vigorous growth, the mucuna would overtake their vegetables and other important legume trees. In Savaia, land area was not an issue since one household has, on average, 39.54 acres of land and 12.30 acres was under taro cultivation. However, the growth of the plant was

an inconvenience for them particularly if they use it as a fallow crop. Farmers said that they did not have the time to leave the mucuna for eight months in order to harvest seeds. In some cases, they would like to bring the area under cultivation and a waiting period of eight months was not practical.

5.2.2.1.3. Tradition

This was defined as the preservation of traditional systems that ensures they can manage the various risks associated with farming, including natural disasters to ensure their food security. Farmers explained that their current system is their source of food and income, it is also important in times of natural disasters. Their plantations sustained their families after natural disasters until families overseas can send money and aid arrives. They do not want to take the risk of using the mucuna because they are uncertain about its benefits. In addition, farmers also said that the use of dadap provides nutrients for their soil and shade for them when they work. Again, farmers are reluctant to change from a practice that has withstood the test of time to a system that has not shown obvious benefits.

5.2.2.2. Using Proportional Piling in an Analytic Hierarchy Process

Proportional piling has been used extensively as a Participatory Rural Appraisal (PRA) tool. It was previously used on remittances study by (Le De, et al., 2014) in Samoa. Proportional piling is defined as "an interactive method of employing 'visuals and tangibles' to generate a discussion, the disagreement and eventually a consensus" Elhadi, (2011, page: 1). It makes data collection easier and allows for decision-making. AHP strives to identify trade-offs between various factors using pairwise comparisons. The two-way pairings often result in consistent answers for participants unfamiliar with making such comparisons. Therefore, proportional piling could improve the AHP results by providing a more tangible visual for respondents and reduce respondent fatigue by reducing the number of pairing (Watson, 2001; Elhadi, 2011).

For this study 80 farmers from Siufaga, 80 farmers from Savaia and five extension officers participated. Most of the current extension officers were excluded because according to a key informant, they did not participate in the introduction of mucuna into the respective villages. To

facilitate the process of data collection, two assistants were hired from the village of Siufaga and three from Savaia. Training was conducted with the assistants on the goals of the research, the use of proportional piling in the study, and data recording. A recording sheet was used to note the socio-demographic and the weight (using the number of stones) allocated for each of the criteria and the alternatives.

The goal of the research was introduced to the respondent and farmer's approval was sought before the exercise took place. Different colors were used to categorize each of the criteria and the factors that comprise them. For example, yellow was used for the criteria (Economics, Extension, and Traditional), green was used for the alternatives of Economics, white was used for the alternatives of Traditional and orange was used for the alternatives of Extension. Paper plates were used and on each plate, the criteria and alternatives were written on colored cardboard. The purpose of the exercise was explained to each farmer and they were given 15 stones. They were asked to allocate all 15 stones between each of the choices such that the numbers of stones allocated represented the relative importance. Once one choice was made, the plates would be changed to the next set of options and the farmer was asked to go through the same exercise.

Respondents only had to answer four questions, which produced three sets of pairwise comparisons for each question. The same exercise was repeated for the extension officers using the same color-coded plates and stones used for the farmer's exercise. The same options used in the exercise with the Siufaga and Savaia farmers were used with the extension officers. Figure 13 and 14 illustrate how the exercise was done.

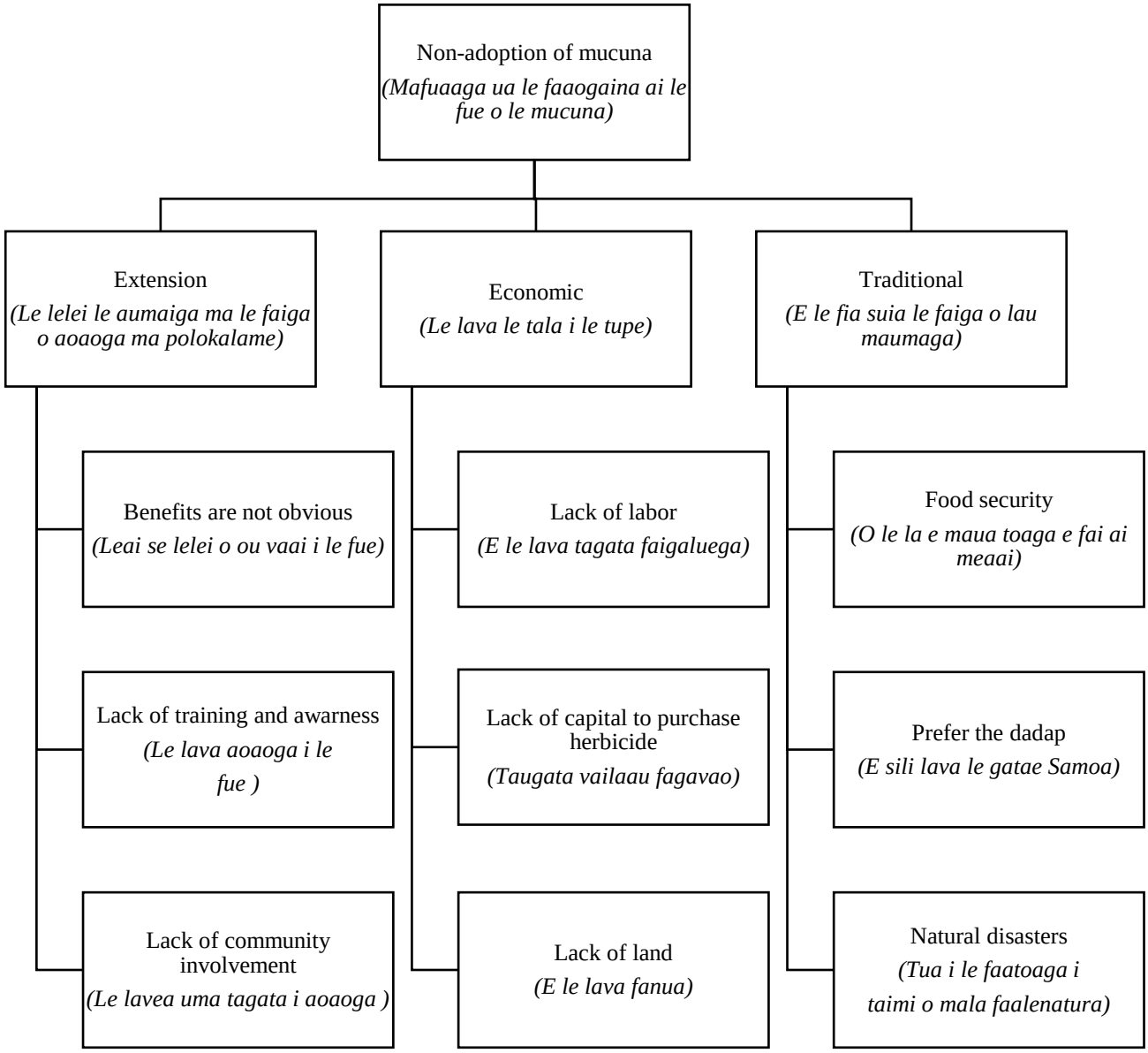

Figure 13: General categories and specific components that farmers perceived as the primary reasons for not planting mucuna as a cover crop (sample of results from the village of Siufaga, Savaii)[33].

[33] The only difference between the AHP framework between Savaia and Siufaga was the lack of land. Siufaga highlighted this as their alternative, whereas farmers from Savaia highlighted inconvenience in the use of the mucuna.

The following is an example of a matrix pairwise comparison between the objectives and the criteria (Table 27).

Table 27: Matrix pairwise comparison between the criteria and the alternatives

	Economic	Extension	Traditional
Economic	1	3	7
Extension	0.33	1	0.20
Traditional	0.14	5	1
	Lack of labor	Lack of land	Herbicide is expensive
Lack of labor	1	8	5
Lack of land	0.13	1	0.50
Herbicide is expensive	0.20	2	1
	Food security	Natural disasters	Dadap is best
Food security	1	2	7
Natural disasters	0.50	1	0.17
Dadap is best	0.14	6	1
	No obvious benefit	Not all members involved	Not enough education
No obvious benefit	1	2	4
Not all members involved	0.50	1	0.11
Not enough education	0.25	9	1

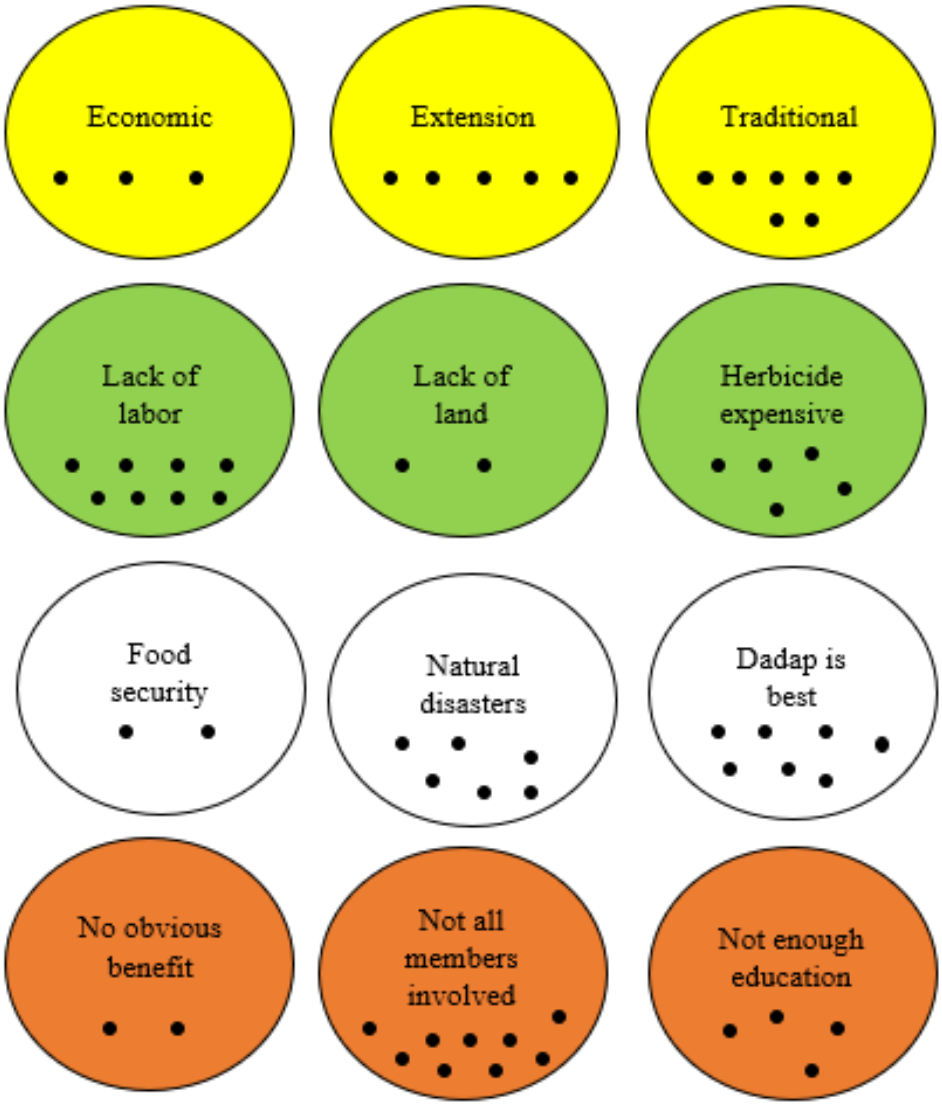

Figure 14: Proportional piling example to indicate the reasons for the non-adoption of mucuna. Each colored circle represents the plates and the dots represent the number of stones allocated for each decision. The example of the values used is based on the responses from one of the farmers in the village of Siufaga.

5.2.3. Data analysis

The following explains how AHP and Spearman Rank correlation was used to analyze the data collected for this study.

5.2.3.1. Analytic Hierarchy Process (AHP) analysis using SuperDecisions

Pairwise comparisons were developed between the criteria and for the alternatives, based on the proportional piling results. Each set of pairwise comparisons using the AHP was entered in excel and converted into ratios and normalized Pairwise comparisons were made using the SuperDecisions software, which was developed by the Creative Decisions Foundation (Creative Decisions Foundation, 2017). This software was used to analyze the data collected from the 80 village farmers in Siufaga, 80 villager farmers in Savaia and the five extension officers taking the ratio for each factor considered. The geometric mean for each group of pairwise comparisons was entered in SuperDecisions using the direct entry method after normalization.

According to Saaty (2001), an inconsistency ratio of less than 0.10 is considered acceptable and that a large inconsistency of (> 0.10) indicate a lack of coherent understanding which may lead to the wrong decision. In this case, the use of direct entry in the software resulted in consistency ratios close to 0.

5.2.3.2. Spearman Rank Correlation (r_s)

Spearman Rank Correlation is a non-parametric measure of correlation between two ranked variables (University of West England, 2017). The Spearman Rank Correlation is denoted using the Greek letter rho (ρ) or r_s. Spearman Rank Correlation measures the strength of association between two variables. The strength of the relationship is expressed as a single value between -1 and +1, this value is called the correlation coefficient. If the correlation coefficient is closer to +1, this indicates a positive relationship or correlation between the two variables. If it is closer to -1, it denotes a negative relationship. If the correlation is 0, this illustrates no relationship between the variables.

The formula is expressed as:

$$rs = 1 - \frac{6\Sigma di^2}{(n^2 - 1)}$$

Where: r_s = Spearman Rank Correlation

d*i* = difference in paired ranks and

n = number of cases

Spearman Rank Correlation uses ranks rather than the continuous data and can be used in cases where the assumptions of Pearson's Bivariate Correlation (continuous-level variables, linearity, heteroscedasticity, and multivariate normal distribution of the variables to test for significance) are not met (Wayne, 1990). Spearman Rank Correlation and significant differences in the group ranks were analyzed using SPSS version 23.

5.3. Results

5.3.1. Socio-demographics for the study sites

Tables 28 indicate the socio-demographics of the community members who were involved in the study. Most of the respondents (78.7 percent) from Siufaga completed their education at the secondary level. This was followed by the primary level (20 percent) and just over one percent of the respondents reached the tertiary level. In Savaia most respondents completed their secondary education (76.3 percent). Several respondents also completed tertiary level (18.8 percent) and a smaller number completed the primary level (five percent).

In terms of gender, the majority of the respondents from Siufaga were female (52.5 percent) and only 47.5 percent were male. The mean age for all the respondents was 42, with females being slightly younger (41 years of age) than males (43 years of age). In Savaia, most of the respondents were male (56.3 percent) with 43.8 percent of the respondents being female. On average, the female respondents were slightly older (45 years of age) than the males (41 years of age). The mean age of the respondents in Savaia was 43.

Table 28: Socio-demographics of respondents from Siufaga and Savaia

Variables	Siufaga	n	Savaia	n	Data for Samoa[34]
Educational level					
Primary	20.0%	16	5.0%	4	60%
Secondary	78.7%	63	76.3%	61	51%
Tertiary	1.3%	1	18.8%	15	49%
Sex of respondents					
Male	52.5%	42	56.3%	45	51%
Female	47.5%	38	43.8%	35	49%
Age of respondents					
Mean age for male	43	23 *(SD =14.11)*	41	45 *(SD = 15.45)*	24.2
Mean age for female	41	21 *(SD = 12.91)*	45	35 *(SD = 14.99)*	23.7
Mean age per respondent	42	80 *(SD = 13.44)*	43	80 *(SD = 15.34)*	23.9

SD: Standard deviation

Table 29 shows that most of the respondents from Siufaga were either wives of untitled men (20 percent) or wives of talking chiefs (20 percent). Only 12 percent of the respondents were wives of high chiefs or were unmarried women. The majority of the males interviewed were untitled men (25 percent) with few of the respondents being high chiefs (14 percent) and talking chiefs (nine percent).

In Savaia most of the respondents were untitled men (35 percent). This was followed by the wives of untitled men (19 percent), talking chiefs (17 percent) and wives of talking chiefs (16 percent). Few of the respondents were high chiefs (five percent), unmarried women (five percent) and wives of high chiefs (three percent).

[34] Source of data: Samoa Bureau of Statistics, 2017.

Table 29: Responsibility in the village

Responsibility	Siufaga village (%)		Savaia Village (%)	
Wife of untitled men	20	(16)	19	(15)
Wife of talking chiefs	20	(16)	16	(13)
Wife of high chief	6	(5)	3	(2)
Unmarried women	6	(5)	5	(4)
Talking chiefs	9	(7)	17	(14)
High Chief	14	(11)	5	(4)
Untitled men	25	(20)	35	(28)

Note: Number in parenthesis indicates the value of n

5.3.2. Results of the pairwise comparisons

Table 30 shows the results from the pairwise comparisons. In the village of Siufaga, the farmers prioritized their lack of involvement in the training programs, the high cost of herbicide and land area as the main reasons for the non-adoption of mucuna. The extension officers identified that dadap is best, lack of involvement of farmers in the extension programs and food security as the main reasons for farmer's non-adoption of the mucuna. Savaia farmers saw the use of dadap as better than mucuna, food security and the high cost of herbicide as hindrances to the adoption of the cover crop. Similarly, the extension officers acknowledged food security, dadap, and natural disasters as being the top three reasons for the non-adoption of the mucuna by the farmers.

Table 30: Pairwise comparisons with farmers in Siufaga and Extension Officers on the reasons for the non-adoption of the introduced mucuna cover crop

Option Siufaga village	Weights	Rank	Extension officers	Rank	Option Savaia village	Weights	Rank	Extension officers	Rank
Lack of obvious benefits	0.0688	9	0.0518	9	Lack of obvious benefits	0.0808	8	0.0508	9
Lack of involvement	**0.1465**	**1**	**0.1716**	**2**	Lack of involvement	0.1171	4	0.1073	5
Lack of training	0.1068	7	0.1117	6	Lack of training	0.0893	7	0.1126	4
Insufficient labor	0.1084	5	0.0558	7	Insufficient labor	0.1109	5	0.0999	6
Small land area	**0.1106**	**3**	0.1154	4	Mucuna untimeliness	0.0799	9	0.0915	7
High cost of herbicide	**0.1396**	**2**	0.0534	8	High cost of herbicide	**0.1318**	**3**	0.0687	8
Dadap is best	0.1083	6	**0.2000**	**1**	Dadap is best	**0.1575**	**1**	**0.1881**	**2**
Natural disasters	0.1020	8	0.1119	5	Natural disasters	0.0905	6	**0.1244**	**3**
Food Security	0.1091	4	**0.1285**	**3**	Food Security	**0.1421**	**2**	**0.1566**	**1**

When the farmers and extension officers were asked to rank the main criteria for the non-adoption of the mucuna, the farmers from Siufaga prioritized economic reasons followed by extension reasons and traditional reasons. The extension officers identified traditional reasons, followed by extension reasons and finally economic reasons. In Savaia, farmers prioritized traditional reasons followed by economic reasons and finally extension reasons for the non-adoption of mucuna. Extension officers identified traditional, extension and economics as the second and third reasons respectively for the non-adoption of mucuna by the farmers (Table 31).

Table 31: Pairwise comparison with farmers in Siufaga and Extension Officers on the summarized factors for the non-adoption of the introduced mucuna

Option	Siufaga farmers	Rank	Extension officers	Rank	Savaia farmers	Rank	Extension officers	Rank
Extension	0.3221	2	0.3351	2	0.28716	3	0.27071	2
Economic	0.3585	1	0.2245	3	0.32267	2	0.26019	3
Traditional	0.3194	3	0.4404	1	0.39018	1	0.46910	1

5.3.3. Spearman Rank correlation analysis

Spearman's rank correlation analysis was conducted to identify any relationship between the ranks given by the extension officers and the farmers from the respective villages to the reasons for the non-adoption of the mucuna. For Siufaga, the results showed a slight positive relationship between the ranks of the extension officers and the farmers ($r_s = 0.35$, n = 9, $p = 0.356$). The results from Siufaga were not significant ($p \geq 0.05$). Similarly, no significant difference ($p \geq 0.05$) was found in the results for the extension officers and the farmers in Savaia. However, the Spearman's correlation did show a medium positive correlation between the ranks of the two groups i.e. ($r_s = 0.57$, n = 9, $p = 0.112$).

5.4. Discussion

Extension officers are change agents at the helm of diffusion efforts, making them an essential link between the researcher and the farmers and vice versa (Vanclay, 2004; Anaeto et al., 2012). In Samoa, extension officers are key in the implementation of programs within villages

(Agriculture Sector Plan, 2015-2020; Tuilaepa, 2006). The general assumption made in the diffusion theory is that change agents i.e. extension officers and the intended adopters i.e. village farmers are heterophily in nature. They differ in education levels, technical expertise, social and economic status (Rogers, 2003). These differences inevitably influence their perceptions of the benefits and limitations of the introduced program (Halbrendt, 2014). This study showed clear differences in perceptions between the village farmers to the extension officers about the reasons for the non-adoption of the introduced practice of mucuna as a cover crop. The differences were particularly obvious in the village of Siufaga compared to the village of Savaia.

In Siufaga, farmers saw the lack of involvement of all community members, the high cost of herbicide and small land area as the top three barriers to the adoption of mucuna. Extension officers, on the other hand, identified that farmers preference for dadap over mucuna, lack of farmer involvement in the mucuna training programs and farmers unwilling to take risks due to food security reasons were the top three motives for the non-adoption of mucuna by farmers.

Differences were also seen in the village of Savaia. Farmers identified that dadap was better than the mucuna, their unwillingness to take a risk on a system that has not shown benefits which could affect their food security and the high cost of herbicide as their top three reasons. Extension officers weighted that food security reasons, the use of dadap as being better over the mucuna and farmers unwillingness to change to a new system in case of natural disasters, as their top three reasons for farmers non-adoption of mucuna.

When comparing the responses between the extension officers to the village farmers from Savaia and Siufaga, a moderate correlation was found between the ranks given by the Savaia farmers and the extension officers. When comparing the ranks between Siufaga farmers and the extension officers, the correlation was weaker. The main difference is that Savaia farmers have a comparative advantage in information access compared to Siufaga farmers. In Savaia an extension officer resides in the village in one of MAFs outreach compounds. Siufaga, on the other hand, is considered the more rural of the two villages with limited opportunity to access extension services. According to U.U. (personal communication, January 16, 2016) extension

officers' visit Siufaga only occur when a new program is introduced or to inspect farmer's plantations for the annual agriculture show. Although no adoption occurs in either village, studies have shown that access to relevant information can support farmers in their decision to adopt a new technology (Bohlen et al., 1961; Rogers, 2003; Knowler and Bradshaw, 2007).

Another important finding in this study was that farmers from Siufaga felt less involved in the implementation of programs, which was identified as the primary reason for the non-adoption of the mucuna. The introduction of the mucuna into the village involved a lead farmer, who linked with family and friends. This differed from the village of Savaia where the use of the established council of chiefs helped to facilitate the promotion of the mucuna to other village farmers. Essentially, the use of lead farmers to promote awareness about an innovation is not always the most effective in way of disseminating information to the rest of their community. In fact, they can be a barrier to adoption of an innovation because they are heterophily with respect to the rest of the community members (Rogers, 2003) as seen in the case of Siufaga. With villages in Samoa already having established social structures in the form of the village council, the use of this method by the extension officers in the promotion of mucuna in Savaia created more awareness of the plant compared to Siufaga. However, observations showed that women in both villages were generally excluded from the training conducted through the use of demonstration plots.

One notable difference in the extension officers and farmers ranks was in relation to herbicide use. What the extension officers thought would be achieved with the use of mucuna was contradicted by the farmers. Farmers from both villages highly ranked the high cost of herbicide as a hindrance to mucuna adoption because they saw the plant becoming invasive which would require herbicide to control it. Extension officers, on the other hand, identified this to be the least likely reason for the non-adoption of the plant because one of the reasons for the plant's introduction was to reduce herbicide use and therefore the associated costs.

Despite the comparative advantage in Savaia over Siufaga in terms of access to information, farmers from both villages did not adopt the mucuna. A key area in helping farmers in their

decision-making process is the use of appropriate communication strategies (Rogers, 2003). Effective communication strategies help farmers to reduce uncertainty about a new idea so that a decision can be made to accept or reject it (Bohlen et al., 1961). Essentially, the introduced practice has to be simple to understand, it needs to be compatible with local practices, and farmers need to be able to trial it so that the benefits and limitations can be observed. An essential factor in this decision-making process is time (Bohlen et al., 1961; Rogers, 2003). All these important factors were lacking in the introduction of the mucuna, i.e. (1) The extension officers conducted only two training sessions with farmers from each village. (2) The duration of the demonstrations was nine months. (3) The demonstration plots only showed farmers how to control the mucuna as a fallow crop and in an intercropping system with taro and no demonstration plot compared mucuna to the current practices of dadap.

Literature suggests that it takes at least five to seven years for CA systems to show its long-term potential (Corbeels et al., 2014). In some studies, it can take up to 14 to 20 years from the point of farmer awareness about an innovation to its adoption (Bohlen et al., 1961; Corbeels et al., 2014). In the case of village farmers from Savaia and Siufaga, the study shows that although some awareness was created with regards to the plant, the insufficient time used in the implementation of the demonstrations led to too many uncertainties involved with the plants use. Therefore, farmers were unwilling to take a risk in changing from their current systems which continues to provide for their livelihood to a system that has shown no initial positive benefits (Sulewski & Kloczko-Gajewska, 2014). These uncertainties stem from the poor outreach efforts used by the extension officers to promote the plant. The extension officers did not work long enough with the farmers to promote the plant and to understand farmers' concerns so that adaptation measures can be taken to suit the crop to farmers' conditions.

To understand the poor outreach efforts, a key informant explained that the extension officers are stretched thin, "we are dealing with too many programs" (T.T., personal communication, June 14, 2017). With the continued influx of aid money and donor programs towards the development of the agriculture sector (Agriculture Sector Plan, 2016-2020), extension officers are concerned about achieving specific outcomes in line with the Agriculture Sector Plans and

donor-funded programs (T.T personal communication, December 16, 2016), which are usually restrained by time and funding. Therefore, the utilization of top-down approaches become more "efficient in getting the job done" rather than farmer-focused. Thus, farmers are unwilling to take risks because the tangible benefits associated with the introduced of a program, in this case, the use of the mucuna, are not obvious (Benu & Wangke, 2016).

This study focused more on gaining in-depth knowledge from farmers regarding their reasons for the non-adoption of mucuna. The study did not spend enough time with the extension officers in Samoa to better understand the constraints that they face with the implementation of their work. It is recommended that future studies on the non-adoption of CA practices in Samoa should focus on issues faced by extension farmers e.g. infrastructure and capacity development impediments with their work.

The use of ANP would perhaps be beneficial in future studies because it supports a comprehensive approach to identifying various factors that influence a decision and determine which are most important to individuals and groups. In this study, collecting data based on key informants, participant observations, focus group discussions and in-depth interviews provided a thorough understanding of the situation and an all-inclusive systematic approach to determining gaps between the extension officers and individual village farmers.

5.5. Conclusion

This study showed that gaps exist between farmers and extension officers regarding the reasons for the non-adoption of mucuna. These differences are seen in how farmers perceive mucuna compared to the extension officers. The difference was particularly evident in the village of Siufaga compared to Savaia, this is because Siufaga receives less extension support from the government. Extension officers have a better understanding of Savaia farmers' situation because they have an extension officer living in the MAF site within the village.

In both villages, the cost of herbicide has the largest difference in ranks, suggesting that this is the most substantial difference between the extension officers and the farmers. Extension officers saw mucuna reducing herbicide use for farmers. On the other hand, farmers identified that with insufficient labor, herbicide use would be inevitable with mucuna use due to its vigorous growth. Essentially, the study indicates that the extension officers are anticipating the farmers perceptions and they are not utilizing appropriate communication channels so that the advantages and disadvantages of the cover crop is more obvious.

Future outreach efforts should involve all members of the village including women. Also, to help farmers reduce uncertainty about any CA practices, the extension officers need to conduct more than two training sessions. More time and information are needed to support farmers' decisions to adopt CA practices. Training duration should be done in consultation with the lead farmers, the village council and the farmers themselves. In addition, donor agencies should also be part of the consultation so that they can provide the needed resources and infrastructure to ensure that the outreach efforts by the extension officers become more effective.

Although the current study indicates that the programs were ineffective and that addressing the issue of time is important, it may take years before the adoption of CA practices is realized. Underlying socio-economic factors must be considered, i.e. Savaia farmers may not yet see the need to change their practice since they have large land areas to expand taro production into. Therefore, the situation of each village and farmer needs to be taken into account. However, as a start extension officers need to be provided with the opportunity to conduct proper outreach efforts. Also, all stakeholders especially aid donors need to ensure that the benefit of the communities is foremost and not the desire to achieve institutional objectives.

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Chapter 6

General Conclusion

This study was initiated to understand why farmers were not adopting introduced CA practices at the village level in Samoa. The study hypothesized that labor shortage at the village level was a barrier to the adoption of introduced CA practices and that differences in perceptions of stakeholders involved could also be hindrances to the adoption and continuation of the systems introduced.

The first study provides an overview of all the CA systems introduced. The study found that four programs with a focus on improving soil health for crop production were introduced in 1970, 1980, 2000 and 2010. The results from the on-station and on-farm trials for these programs showed that CA has potential benefits. These include improving the soil moisture content, reducing soil temperature, improving soil nutrient content through improved nutrients such as Nitrogen, Phosphorus, and Potassium. These contributed to increased yield in most of the trials conducted. Despite all the efforts and resources utilized in the implementation of the programs, the farmers failed to adopt the practices introduced because they were not convinced of the benefits of the introduced systems.

Using the example of the ACIAR Soil Health Program where mucuna was introduced as a cover crop into taro plantations, the second study gives a closer look at the reasons for the non-adoption of the practice by comparing its benefits and costs over farmer's current practices. The study found that village farmers in Samoa almost uniformly used CA. This was evident in their taro plantations whereby zero-tillage, mulching, mixed cropping of taro with other vegetables and/or with the dadap or *Gliricidia* legume was observed. These traditional farming methods have helped farmers maintain the health of their soil for many generations. Farmers at this point may not see the need to utilize mucuna as a cover crop as they are able to sustain their families with current yields received. Also, the idea of cover cropping using mucuna had no relative advantage over current practices. The system was too complex and not compatible with current practices and would require farmers to change their mindset and way of farming to implement

the introduced system successfully. Furthermore, the use of the lead farmers by the extension officers resulted in the limited awareness raised within the respective communities because the lead farmers only included their family members in the training. The exception was in the village of Savaia where the lead farmer involved the village council to create awareness regarding the use of the plant. However, since the trials only lasted for nine months, the lead farmers and village council were not given the opportunity to trial and observe the benefits and limitations of the plant for themselves resulting in its non-adoption by those involved.

The third study explored socio-economic and cultural benefits and limitations of the introduced mucuna CA system at the village, and to understand farmers' perceptions of the introduced CA system. The study found that farmers at the village level have adapted their farm management strategies to suit their current limitations such as the use of herbicide to control weeds due to the limited available farm help available. Adapting their systems is important because farmers depend on agriculture for their livelihood and to fulfill their cultural obligations within their village. Therefore, farmers were unwilling to take the risk of changing to a system where the advantages and disadvantages were not yet explicit when current practices work for them.

The final study shows that gaps exist between the extension officers to the village farmers as seen with the AHP analysis. In both villages, the cost of herbicide has the largest difference in ranks, suggesting that this is the most significant difference between the extenders and the recipients. Farmers use herbicide because there are limited family members who can support plantation work. Farmers were concerned that the vigorous growth of the mucuna would result in additional labor required to control the plant. Thus, with limited family members to do this, the use of herbicide was therefore seen to be inevitable. Some of the main reasons why these gaps exist are because extension officers are not utilizing all members of the farming communities in their trials. Furthermore, they are only targeting the lead farmers within the village to be part of the trials. Additionally, the extension officers are not working long enough with the farmers in the implementation of these trials to ensure that the systems can be adapted to suit their local context.

This study found that labor was an issue in the adoption of introduced CA practices as seen in the case of mucuna. Furthermore, differences exist in the perceptions of farmers and stakeholders such as the extension officers resulting in ineffective outreach efforts. However, other factors also contributed to the non-adoption of CA practices such as insufficient time to implement the systems with farmers and to compare these introduced systems over current practices. Furthermore, complexity and non-compatibility of the system would require a change in farmer's mindset to implement the system successfully. Farmer's cultural obligations were also contributing factors to the non-adoption of CA practices as seen in the case of mucuna.

This research suggests that extension officers need to involve all members of the community in their demonstration trials. The duration of the demonstration trials conducted by the extension officers with the farmers should be extended until a point where farmers can make the comparisons between their current systems to the introduced ones. Literature indicates that benefits of CA can take up to seven or more years to realize. It is not clear how long research on the mucuna trials need to be continued for, but extending the duration of the trials with the farmers will be the opportunity needed to address any negative issues that could arise with the system. Essentially, a "one-model-fits-all" mentality should be excluded when taking the research out to the farmers and the systems introduced should be catered to suit the needs of the specific villages. Donors, the government and research institutions should work with the extension officers and farmers in the design of the introduced mucuna program to ensure that the farmer's needs are met and that farmers are given the opportunity to trial these systems for themselves.

It is also recommended that this study is repeated in each of the respective villages where mucuna was introduced so that their problems can be better understood to support the introduction of future CA programs. Essentially, it is suggested that soil analysis take place in all the villages where mucuna was introduced so that the soil health issues for each respective village are targeted and a monitoring scheme established to ensure that farmers' needs are met in the programs introduced. Moreover, the use of the AHP provided a simple approach to understanding gaps between the change agents and the village farmers. The use of this method combined with an understanding of the local context provided a holistic look at the issues of CA

adoption. However, it is recommended that the ANP be used for future studies to see if there are any changes with respect to the results of farmers' decisions.

Based on observations made, culture plays an influential role in farmers decision making with respect to the non-adoption of mucuna, thus future research needs to always take this aspect into consideration for each respective village. In addition, future studies on mucuna perhaps should focus on how the plant could reduce herbicide costs by utilizing different management strategies e.g. time of planting or reducing mucuna fallow duration to cater to farmers current practices. These systems need to be compared to farmer's current practices so that the system can cater to farmers current limitations. Future studies should also consider collecting quantitative data on costs and labor for both systems. Further studies need to consider the soil implications of herbicide use raised by the local farmers as well as the health implications of the overuse of herbicide at the village level.

Appendix 1: Pictorial

Photo 1: My nine-year-old son holding an *oso* used by farmers to plant taro. Photo taken in the village of Siufaga

Photo 2: New patch of taro and bananas grown in an area that has been hand cleared by a farmer: Photo taken in the village of Siufaga

Photo 3: An existing plantation of taro under coconuts which has been cleared using herbicide. Photo taken in the village of Savaia

Photo 4: Watermelon and cucumber plants intercropped with taro. Photo taken in the village of Siufaga

Photo 5: Mucuna growing over lemon and banana trees in the village of Falelauniu